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Working in Heat: A Review of National and International Management Policies in the Construction Industry

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Abstract

Construction workers are particularly vulnerable to the consequences of heat stress due to the nature of work undertaken. With climate change set to increase the prevalence of heat-related illnesses in Australia, action is needed to reduce this burden. This article reviews published literature and government publications to gain an insight into international heat stress management policy and industry practice. Recommendations to improve health and safety policy for construction workers in Australia are given based upon analyse from international findings**.**

Key words: Australia. Heat Stress. Construction Industry. Occupational Health and Safety. Risk Control. Policy.

Introduction

Working in heat is an occupational health and safety risk, with heat stress widely recognised as an occupational hazard pertaining to environmental ergonomics (Dianat et al., 2016; Safe Work Australia, 2017). Heat stress occurs when intensive physical work in an environment of high heat exposure coupled with inadequate rehydration results in the body not being able to cool itself, causing core body temperature to rise beyond 37°C (Mazlomi et al., 2016; Nunfam et al, 2018). This rise in body temperature provokes heat strain, a physiological response intended to maintain thermal equilibrium, which when overwhelmed can lead to illnesses such as heat cramps, heat rash, heat exhaustion and heat stroke, which can be fatal (Rowlinson et al., 2014; Spector et al., 2016). These aforementioned heat-related illnesses impact worker performance and productivity and can lead to hospitalisation (Spector et al., 2016).

Rowlinson et al. (2014) identifies six key factors that impact heat stress, these are: air temperature, radiant heat, wind speed, the metabolic heat generated through physical activity, humidity, and the ‘clothing effect’ that moderates heat exchange between the environment and the body. The heat strain experienced by a worker can also bee influenced by behavioural and physiological factors, including gender, physical fitness, age, use of alcohol or drugs, hydration status and a range of medical conditions (Yi & Chan, 2015). Implementing heat stress protective measures offers numerous benefits such as an improved sense of wellbeing, improved worker productivity, and a decreased rate of workplace injuries and accidents (Rowlinson et al., 2014; Yi & Chan, 2015).

Workers in the construction industry are particularly susceptible to heat stress because of the highly demanding, strenuous physical nature of work, coupled with prolonged exposure to direct sunlight (radiant heat) and in some countries in hot and humid working conditions (Spector et al., 2016; Varghese et al., 2018; Yang & Chan, 2017; Yi & Chan, 2017). Workers in the construction industry are second only to agricultural workers as groups of workers most likely to be affected by climatic heat stress (Baizhan & Andrew, 2018). Further, heat exposure and stress induces other construction site injuries through mental impairment, personal protective equipment (PPE) misuse, and physical fatigue (Mazlomi et al., 2016; Rowlinson et al., 2014).

By 2030 globally, roughly 1 million work life-years are expected to be lost as a direct result of occupational related heat stroke fatalities, with reduced productivity resulting in the loss of 70 million work life-years (Flouris et al., 2017). Between 2011 and 2014 in the U.S, environmental heat exposure was responsible for close to 14,000 non-fatal work injuries involving lost days of work and 144 worker deaths (Varghese et al., 2018). Comparably, a study conducted by Xiang et al. (2013) in Adelaide, South Australia, found that occupational injuries are statistically more likely to occur in hot conditions resulting from workers suffering impaired concentration and mental judgment, with there being an increased risk for injuries arising from slips, trips and falls, and contact with objects and equipment. Keeping to Australia, an annual labour productivity loss of AU$6 billion is attributed to the consequences of heat stress (Jia et al., 2019).

In response to the negative health outcomes and productivity loss arising from occupational heat stress, international agencies formulated standards that postulate the upper safe limits of heat exposure. The International Organization for Standardization developed the WetBulb Globe Temperature (WBGT) in 1982 as a universal standard for safe heat exposure, as it accounts for solar radiation, air temperature, wind speed, humidity, and their combined effects (Nerbass et al., 2017). Strategies for working in the heat are mentioned in guidelines and the regulations of different countries such as Australia, U.S, U.K, Hong Kong, Japan and other developed economies. With there being few or no specific regulations in developing countries (Varghese et al., 2018). In spite of a general 'duty of care' found in legislation, the hazard of working in heat is not specifically tackled. As a result, less diligent employers may be more likely to be non-compliant with guidelines and regulations for varying reasons (Safe Work Australia, 2019; Varghese et al., 2018).

With climate change expected to increase temperatures and humidity in Australia (Carter et al., 2020), it is paramount to review policies and construction industry guidelines in countries which are profoundly affected by heat stress and cover the climatic conditions experienced by, or are likely to be experienced by in the future, workers in Australia. Tropical/humid (Hong Kong and India), arid/desert (Saudi Arabia), and temperate (USA). This review aimed to investigate heat stress management in the construction industry from the above-mentioned countries, and make recommendations to improve Australian regulations and industry guidelines based on international best practice.

Methodology

To investigate the effects of heat stress in construction work, factors that contribute to it and risk control measures around the world an initial search was conducted using Curtin University's Library Catalogue, Science Direct and PubMed databases. A search using the Science Direct database with the keywords 'heat stress' and 'construction' provided 113,199 results. The search was then refined to display peer-reviewed research and review articles published between 2010 and 2020 that yielded 45,446 results. A second search conducted using the Curtin University's Library Catalogue with the same search criterion provided 63,026 results. A final article search conducted using the PubMed database with the same search criterion yielded 40 results. Further search was conducted using Google with the keywords 'construction heat stress' and 'work health and safety' which returned 80,700,000 results. Results from credible international and Australian agencies such as Safe Work Australia, the National Institute for Occupational Safety and Health, and the Hong Kong Construction Industry Council have been included in this literature review. From the searches conducted, 31 articles were reviewed that considered heat stress and the construction industry. Articles that did not have a direct link to occupational heat stress and that appeared in all 3 database searches were excluded. Three papers were obtained through snowballing search. A total of 23 articles, one piece of model legislation, and three publications from government sources are cited in this review.

Discussion

Several countries have varying similarities in policies and industry guidelines on the management of heat stress for the construction industry, yet there are unique differences between them that can help improve policy and industry best practice in Australia.

What are the recommendations in Australia?

No laws explicitly concerning to work in hot weather were located among Australian Work Health and Safety (WHS) legislation. However, WHS legislation requires that employers ensure, so far as is reasonably practicable, that workers are protected against hazards arising in the workplace that may cause harm to their health or safety. In state and territory regulations (other than the state of Victoria), it is specified that these hazards include the extremes of temperature, such as extreme heat (McInnes et al., 2016; Xian et al., 2015).

All state and territorial regulators have resources and information that can be accessed via their websites, offering guidance on working in extreme temperatures (McInnes et al., 2016). With the practice of heat stress management in the construction industry generally focused on three distinct interventions; hydration, self-pacing at work (decline in metabolic rate to a lower, safer level is a protective response to heat stress), and the Thermal Work Limit (Al-Bouwarthan et al., 2019; Jia et al., 2019). Other preventative measures include that of using automation where possible, work-rest scheduling, induction and heat-stress management training, the provision of shade and/or air-conditioned break areas and appropriate PPE. The Construction, Forestry, Mining and Energy Union (CFMEU) have made specific heat stress management guidelines, and suggest that if the temperature rises above 37°C, all work should cease unless working in an air-conditioned area. Nevertheless, the non-mandatory nature of the CFMEU guidelines raises the problem of non-compliance (Xian et al., 2015).

The high percentage of participants not satisfied with current heat prevention measures in an Australian cross-sectional survey of Occupational Hygienists by Xiang et al. (2015) suggests there is a necessity for further development of current heat management policies in the Australian workplace. With a measurable increase in temperature expected across Australia, policy update should be aimed at long-term hardy heat stress policies that are specific to occupations most likely to be affected by such increases, such as the construction industry (Carter et al., 2020).

Saudi Arabia

Excessive heat exposure poses major risks to hot-climate construction workers. With Saudi Arabia being one of the hottest countries in the world, the country has unique heat stress policies that are not seen in Australia (Al-Bouwarthan et al., 2019; Safe Work Australia, 2017). In Saudi Arabia, the WBGT value measured during outdoor construction work frequently exceeds, by high percentages, the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Value, indicating a high level of heat stress is present during both heavy and moderate workloads (Al-Bouwarthan et al., 2019). In response to the hazard of heat stress, the Saudi Ministry of Labor and Social Development adopted a rule in 2010 that bans outdoor work daily between 12 and 3 p.m. during the summer months. This regulation, however, is enforced irregularly and the temperatures during unrestricted hours can still be extremely high (Acharya et al., 2018; Al-Bouwarthan et al., 2019).

A 2019 study by Al-Bouwarthan et al. found that there is a lack of empirical evidence about the effectiveness of this regulation in reducing heat stress, as majority of construction sites do not comply with the government ban and continue with work. Additionally, there have been reports of dozens of workers who have died from heart attacks triggered by heat strain by both the Indian and Nepalese embassies, highlighting the need of enforcing the regulatory standard (Acharya et al., 2018). Other heat stress standards found to be in place at Saudi Arabian construction sites include; adequate PPE, loose fitting breathable clothing, provision of fresh potable water, availability of shaded rest areas (although this varies by job and site), and the practice of self-pacing by workers (Acharya et al., 2018; Al-Bouwarthan et al., 2019). Construction sites abide to heat management guidelines and comply with the stop-work regulation on a site-by-site basis, highlighting the need for stronger enforcement.

Hong Kong

In Hong Kong, around 20% of work time in the summer months put workers at high risk of heat stress due to the cities hot and humid weather (Yi & Chan, 2017). Under Hong Kong legislation, every employer must, so far as reasonably practicable, ensure the health and safety of all employees at work. This results in Hong Kong's heat stress guidelines being very similar to that of Australia's (Hong Kong Construction Industry Council [HKCIC], 2013; Safe Work Australia, 2017). In 2008, the Construction Industry Council (CIC) published an informative guideline on the protection of workers in hot weather, which has since been updated. Safety measures outlined in the guideline include; appropriate work arrangements, allowance of workers to take regular breaks, the provision of cool down facilities/shelter, main contractors should provide sufficient cool potable water, appropriate PPE and light coloured, loose fitting clothing, provision of relevant training for construction workers before summer months (heat stress assessment, risk factors and symptoms, respective safety measures etc.) and the use of mechanical aids to reduce physical work load on workers (Chan et al., 2015; HKCIC, 2013).

Uniquely, the guideline recommends, an additional 15-minute rest period during the hot summer months (May to September) to help deal with humid conditions on top of the routine 30-minute rest period for construction workers during the afternoon work session (HKCIC, 2013). Contractors and subcontractors are further recommended to measure and issue an alert if the onsite WBGT exceeds threshold (Yi & Chan, 2017). To comply with legislation, industry participants are expected to follow the recommendations outlined in the CIC guidelines to ensure health and safety protection to construction workers (HKCIC, 2013). These recommendations are close to that of Australia, with unique differences to help deal with Hong Kong's humid and hot climate.

United States of America

Between 1992 and 2016 more than a third of all occupational deaths in the U.S were either directly or indirectly caused by heat exposure, with 17 construction workers dying as a direct result of heat-related stresses in 2015 (Dong et al., 2019; Yi & Chan, 2017). These outcomes highlighted the need for updated industry standards, prompting the National Institute for Occupational Safety and Health (NIOSH) to publish amended recommendations employers should follow to prevent heat stress and heat-related illnesses (Jacklitsch et al., 2016). While not a mandate, the recommendations are appropriate guidance that can be used to prevent occupational heat-related illnesses to comply with the Western Australian Occupational Safety and Health Act general duty of care clause (Jacklitsch et al., 2016).

The recommendations fall under the following (Jacklitsch et al., 2016):

1. Assess the risk – use WGBT and occupational exposure limits to protect workers. Screen workers for heat intolerance.
2. Limit exposure – encourage workers to take breaks. Wear light-coloured, loose fitting, breathable clothing. Schedule hot jobs for cooler parts of the day. Require a worker to stop working when they feel heat-related discomfort.
3. Reduce metabolic heat load – mechanise the physical parts of work where possible. Increase the size of the crew to reduce the workload on each worker.
4. Enhance heat tolerance – develop a plan to acclimatise workers to heat.
5. Encourage hydration – adequate provision of fresh, cool drinking water. Provision of individual not communal drinking cups.
6. Know the symptoms of heat related illnesses (heat stroke, exhaustion and cramps) and the steps to take when they occur.

7. Create a heat alert program – form a Heat Alert Committee each year by mid-April that includes representatives of the workers, management and a qualified healthcare provider or health and safety professional. Have procedures in place to deal with extreme heat alerts which requires managers and supervisors (in writing) to ensure adequate supplies, training and provision of aforementioned recommendations.

These recommendations are similar to both Australia's and Hong Kong's, highlighting cultural and economic similarities.

India

India has the world's highest accident rate among construction workers at 165 out of every 1000 workers (Dutta et al., 2015). With construction workers being particularly vulnerable to health risks because of few legal protections, increased exposure to environmental factors, economic disadvantages and a poor safety culture (Dutta et al., 2015; Srinivasan et al., 2016). Due to the lack of enforceable guidelines and standards, workers report adopting various strategies on their own to prevent heat-related illnesses such as; drinking copious amounts of water, frequent resting in the shade, and habitually sprinkling their face with water. Most workers report water as an important factor for coping in India's extremely hot and often humid climate (Dutta et al., 2015; Srinivasan et al., 2016). When there is a lack of safe drinking water available on site, workers typically supply their own water from home to drink at work (Dutta et al., 2015).

In the qualitative study by Dutta et al. (2015), none of the workers interviewed stated they were provided gloves and sunglasses, with workers feeling that the use of sunglasses and appropriate PPE would help cope with heat stress. The study supports the establishment of a tropical and/or a India specific heat exposure guidelines that could simultaneously be worker protective and realistic in India's given climate. It must be noted, however, that there is a current lack of literature into heat stress in India, thus it is hard to review current heat management strategies in place.

Recommendations

Based on above analysis, it is recommended that the following amendments be made to Australian health and safety policy and guidelines in regards to heat stress management:

1. With humidity in Australia expected to increase due to the effects of climate change (Carter et al., 2020), there should be a mandatory and enforced regular 30-minute rest period for construction workers with an additional 15-minute rest period being allowed for workers during hot summer months (HKCIC, 2013).
2. The formation of a Heat Alert Committee (as recommended by NIOSH) in each workplace by mid-October yearly which includes representatives of workers, management and a qualified health and safety officer. This committee must ensure there are procedures in place to deal with extreme heat as outlined in Australian guidelines, and that these recommendations are met in writing by managers and supervisors (Jacklitsch et al., 2016).
3. There should be mandatory regular use of the WGBT and occupational exposure limits (such as the ACGIH Threshold Limit Value and the Thermal Work Limit) at worksites to protect workers (Al-Bouwarthan et al., 2019; Jacklitsch et al., 2016).
4. Lastly, no work should be permitted between 12 and 3 p.m. daily during the summer months in the Outback, or where temperatures often exceed 35°C, with construction work allowed to start or finish earlier to accommodate for this. As mentioned previously, Al-Bouwarthan et al. (2019) found that there is often non-compliance with stop-work regulations, therefore recommended strategies should be added to law via amendments to the WHS Regulations – contractors, subcontractors and officers failing to comply will be subject to sanctions under section 5 of the WHS Act (Safe

Work Australia, 2019), leading to improved compliance.

Further, it is apparent that research and policy development is radically needed to improve health and safety outcomes and quality of life for Indian citizens and those in developing economies.

Conclusion

The construction industry is particularly susceptible to heat stress because of the nature of work undertaken. With climate change expected to increase environmental temperature and humidity in Australia, concerted action is needed to mitigate the effects of occupational heat strain, and the anticipated rise in environmental heat stress. This review presents recommendations for amended policy focusing on heat stress and hot weather strategies from countries which have climatic patterns Australia currently has or is likely to have in the future. With occupational injuries and fatalities statistically more likely to occur due to the effects of heat stress on human physiology, and with an annual labour productivity loss of AU$6 billion attributed to the consequences of heat stress, perhaps implementing recommendations made will reduce the burden of heat stress on Australia's economy and improve the quality of life of construction workers.

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Development of an Airline Cabin Crew Pre-Task Hazard Assessment Tool: The Identi-Fly Hazard Booklet

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Abstract

Airline cabin crew are exposed to a broad range of hazards and associated risks which can be difficult to manage with any failings leading to grave consequences for both employees, passengers and airline businesses as a whole. Airlines must therefore strive to develop new strategies for the innovative management of hazards and work towards reducing their risks to as low as reasonably practicable (ALARP). This paper discusses a pilot program to improve a large Australian commercial airline's management of the hazards faced by cabin crew. It details the introduction of a program for the development, implementation and evaluation of a pre-task identification hazard assessment tool called the 'Identi-Fly' booklet. Results indicated that there was an improvement in the hazard identification capabilities of the cabin crew and the program promoted a stronger interdependent safety culture amongst the work group that enabled cabin crew to protect both themselves and others against the major hazards they encounter. The success of the program would appear to assist in improving an airline's overall safety management objectives whilst also supporting the more holistic objective of the cabin crew department to become incident and injury free.

Key Words: Cabin Crew. Aviation. Hazard Identification. Hazard Awareness. Personal Risk Assessment Tool. Safety Culture. Injury Prevention.

Introduction

Airline cabin crew are exposed to an abundance of hazards within their workplace due to limitations of space and functionality and these limitations hinder an airline's ability to effectively manage the hazards and risks experienced by their cabin crew. Airlines are also challenged by strict regulatory constraints and have very little scope, power or ability to make modifications to the aircraft cabin environment making work health and safety engineering control measures often implausible (Cooper, 2000). As a result of this, managing the behaviour of cabin crew and instilling a safe working culture is a vital defence against the manifestation of cabin crew injuries and incidents.

A large commercial airline operating in Australia, hereinafter referred to as 'the airline', had no pre-task hazard assessment tool in place and instead relied heavily upon its cabin crew following the airline's standard operating procedures (SOPs) and not deviating from the prescribed manual specifications.

However, in times of high workload, distraction, fatigue, or perceived company pressures, reliance upon SOPs may not be sufficient as the sole line of defence against the formation of an incident or the onset of injury (Reason 1997). According to the Occupational Safety & Health Administration [OSHA] (OSHA, 2002), personal risk assessment tools commonly known as a *Take Five*, *Job Safety Analysis* (JSA), *Job Hazard Analysis* (JHA), *SLAM: Stop, Look, Assess, Manage* or *Safety Observation Forms*, are an effective strategy to improve hazard identification and safety culture within a workplace (OSHA, 2002). These tools are used in high-risk industries including oil and gas, rail, transport, mining, construction industries and have been attributed to instilling greater hazard awareness amongst workers, resulting in a reduction of work-related injuries. They have been linked to an improved culture of reporting hazards and the implementation of early workplace health and safety intervention methods for safety management (OSHA, 2002).

Hazards in a Cabin Crew Work Environment

According to Agampodi et al. (2009) working in the unique environment of an aircraft cabin exposes flight attendants to an array of hazards and places them at high risk of sustaining a work-related injury (Agampodi et al., 2009). The airline's cabin crew, like others in the industry, are subject to various intrinsic hazards and the airline has already seen many of these hazards manifest into contributing factors in recent cabin crew incidents and injuries (The Airline, 2013).

One of the biggest threats to cabin crew safety is turbulence, which according to the Australian Transport Safety Bureau (ATSB), is attributed the majority of serious injuries experienced by Australian cabin crew. In particular, clear-air turbulence, which is often unexpected and sudden in its onset, can cause cabin crew to be forcefully thrown about the cabin or struck by unsecured objects, resulting in injury (International Air Transport Association 2012). Cabin crew are also exposed to hazardous manual tasks within the aircraft cabin, with common mechanisms of ergonomic harm including heavy service carts, aircraft doors, atlas boxes, overhead lockers and baggage. Many of the tasks completed by cabin crew also involve pushing and pulling, awkward movements, twisting, overreaching and poor posture whilst working in small spaces such as the galley and aisles (Glitsch et al., 2007). A 2007 British study of flight attendants found that manual handling attributed to 26% of all reported injuries amongst cabin crew (Civil Aviation Authority, 2012). Furthermore, other studies of flight attendants have also noted pushing, pushing or lifting as a leading cause of cabin crew injury and documented this injury mechanism as predominately resulting in musculoskeletal injuries of strains and sprains in the upper limbs and back (Agampodi et al., 2009).

Exposure to slips, trips and falls and working at heights are also significant hazards within cabin crew work environments. According to the Civil Aviation Safety Authority (2000), cabin crew are at particular risk of suffering a slip, trip or fall due to the hazardous and unstable working conditions of the aircraft cabin. Cabin crew may also slip in wet surface areas of galleys and trip on passenger items such as bags, legs or feet that make their way into the aisle (Civil Aviation Safety Authority, 2000). Cabin crew are exposed to a serious working at heights risk of falling from an unprotected open aircraft door. This may occur during the opening or closing of doors, the removal of platforms or stairs or when aerobridges or steps are not positioned properly (Health and Safety Executive, 2015).

Other hazards that cabin crew are exposed to include a range of thermal, biological and chemical hazards. Thermal hazards are present in the form of hot liquids and ovens, which may cause burns and scalds and common biological hazards include exposure to viruses from ill guests, needle-stick injuries and contact with bacteria from lavatories and galley areas (Civil Aviation Authority, 2012). Chemical cleaning products also present a risk, as when these chemicals are used in combination with the aircraft cabin environment of low relative humidity and airborne pollutants, they may prove hazardous to cabin crew by exacerbating contact dermatitis (Leggat & Smith, 2006).

In order to improve a large Australian commercial airline's management of the hazards faced by their cabin crew, a pilot program was developed and tested, with a view to increasing the ability of cabin crew to identify hazards in their usual work environments.

Pre-Task Hazard Assessment Tool

In order to assist the airline to enhance their cabin crews' identification of hazards and manage the risks present within their cabin crew department to as low as reasonably practicable (ALARP), a project was undertaken to develop, implement and evaluate a personal hazard assessment tool tailored especially for the airline's cabin crew. The aim of the project was to work in conjunction with the airline's current work health and safety (WHS) strategies but to further develop a personal hazard assessment tool for cabin crew that would facilitate behaviour change amongst the workgroup and assist the airline to accomplish their holistic view of striving to be incident and injury free. Furthermore, the tool was also targeted at improving and promoting a positive safety culture amongst the workgroup and aimed towards enhancing an 'interdependent' safety culture as described by the 'Bradley Curve' (DuPont, 2015).

To achieve this, a pre-task hazard assessment tool was developed with the intention of increasing the cabin crew's hazard awareness capabilities, which would also empower them to instill the characteristics of an 'interdependent' safety culture whereby they would take action to mitigate hazards and risks in their work environment in order to protect themselves and others from harm (DuPont, 2015). The project's scope involved developing, implementing and evaluating a cabin crew pre-task hazard assessment tool to align with relevant codes of practice, company policies and procedures as well as applicable International Air Transport Association (IATA) legislative requirements. The project was completed over a 14 week timeframe and involved 30 Melbourne based cabin crew who volunteered to form the cabin crew workgroup and participate in the pilot program for the development, implementation and evaluation of the personal risk assessment tool. The cabin crew workgroup agreed to complete two online surveys and use the hazard identification tool over a period of 2 weeks in an operational sense whilst flying 'out online'.

Methodology

In order to structure the project in the best way possible, the project was organised into 3 distinct stages, which included (1) collection of initial data and survey development; (2) formation and implementation of the pre-task hazard tool known as the Identi-Fly booklet; and (3) review and evaluation of Identi-Fly booklet use via data collection. The research project for the cabin crew pre-task hazard assessment ran for 14 weeks from May-August and involved 30 Melbourne, Australia based cabin crew who volunteered to participate in the project. Throughout the project, the cabin crew participants were required to complete two surveys, one before using the pre-task hazard assessment tool and a reflective survey after using the pre-task hazard assessment tool during their flying duties. Both surveys involved a combination of quantitative and qualitative assessments to ascertain retrospective information and establish any changes of the workgroup's safety culture and knowledge of workplace hazards after using the personal risk assessment tool. Biometric data of the workgroup involved in the project can be viewed in the following table.

Table 1 Biometric Data of Survey Respondents

Category	Individual Qualities	Survey 1: Perception of Hazards	Survey 2: Reflection Survey
Role	Cabin Crew	14	14
	Cabin Supervisor	13	10
Gender	Male	14	14
	Female	13	10
Age	18-24	1	1
	25-34	15	14
	35-44	7	6
	45-54	4	3
	55-65	0	0
Time in role	Less than 6 months	0	0
	6 months- 2 years	0	0
	2-5 years	11	9
	5-10 years	12	11
	More than 10 years	4	4

Hazard Research and Survey Development

The first stage of the project involved the collection of hazard data to develop suitable questions for the two surveys. The first survey would be focused on the 'Perception of Hazards', completed before using the pre-task hazard assessment Identi-Fly booklet and the second one would be the 'Reflection' survey, completed after using the pre-task hazard assessment Identi-Fly booklet. Utilising the cabin crew injury mechanism data supplied by the airline, hazard information was analysed and categorised into damaging sources of energy to determine the types of hazards and energy present within the cabin crew work environment. Once this was established, questions for the two surveys were then developed to assess whether the hazards identified by the cabin crew surveyed were consistent with the existing reported injuries amongst the wider workgroup. Further questions were also added to both surveys to ascertain safety climate information, this included the addition of a broad range of 5-point Likert scale questions to gather quantitative information about the safety culture of the workgroup. All answers from both surveys were kept anonymous and the cabin crew completed both surveys individually via a link sent out to the cabin crew workgroup to an online questionnaire form.

Development and Implementation of the Identi-Fly Booklet

Using the data obtained from the first Perception of Hazards survey, knowledge gaps in hazard-awareness amongst the workgroup were identified and the hazards that the cabin crew consistently failed to recognise were also pinpointed. This information was then used to formulate the content of the pre-task hazard assessment Identi-Fly booklet development. The booklet consisted of 10 short tailored questions that were appropriately targeted to help close the gaps in knowledge of the cabin crew and focus the workgroup's attention towards raising greater awareness of previously less identified hazards. The creation of the booklet also involved considering the airline's branding as well as formatting, printing and the overall 'look and feel' of the booklet. Consideration was given to the design aspects of the booklet to ensure it was both appealing and convenient for cabin crew to use, but also durable.

Each participant of the workgroup was given a copy of the Identi-Fly booklet, along with a set of instructions, to use during their normal flying duties for a period of two weeks. Cabin crew were instructed to use their Identi-Fly booklet either before a duty in briefing, a long-term-around/aircraft swap or during flight if time permitted. They could choose to complete the hazard assessment as an individual or with their cabin crew colleagues to discuss and record any hazards that they may encounter, along with any actions they could take to avoid harm. They were advised to answer the questions in note form to remind them of hazards to look for or actions they intended to take to protect themselves and their crew. They were encouraged to carry the booklets in their pockets. Once the cabin crew had used the Identi-Fly for two weeks, they were requested to do the second reflective survey.

Results

There was a slight decline in the response rate between the first and second surveys. The Perception of Hazards Survey had a response rate of 90% (27 respondents) and the Reflection Survey had a response rate of 80% (24 respondents).

Survey One – The Perception of Hazards Survey Results

It was evident from the results of the Perception of Hazards survey that despite 96% of the cabin crew reporting that they knew what a hazard was, many failed to correctly identify a range of workplace hazards presented to them. The survey indicated that cabin crew had a strong knowledge of the types of hazards that they regularly encountered in their workplace, with 95% of respondents identifying turbulence, manual handling and fatigue as workplace hazards. Coincidently these particular hazards had also been the topics of previous WHS, SOP and educational training packages delivered to all cabin crew. This suggests that cabin crew have so far responded well to the WHS related coursework delivered training and that these training modules have been well received and effective in increasing cabin crew's awareness of particularly prominent hazards in their workplace. However, there were also noticeable gaps in knowledge amongst the workgroup in relation to identifying other hazards including gravitational, biological, thermal and electrical damaging sources of energy. A summary of survey one results is presented in table 2.

Survey Two – Reflection Survey

The results from the Reflection Survey showed that the Identi-fly booklet generated a significant improvement in the identification of nearly all types of hazards. The greatest improvements were seen regarding the identification of hazards involving gravitational, thermal, chemical and acoustic damaging sources of energy. The most positive changes included the workgroup noticing electrical appliance, UV/sunlight, falls from height and contaminated crew or passenger food. Overall the workgroup feedback from the reflection survey was very positive with cabin crew making comments such as "handy tool and a good device for use in pre-flight briefings to help heighten awareness of hazards in our workplace".

Conversely, the Reflection Survey showed that the Hazard Identification Table included in the Identi-fly booklet was not a completely helpful tool and was not effective in increasing the workgroup's overall competency for identifying workplace hazards. Rather, the results from the questions into damaging types of energy produced relatively poor results and were detrimental to the overall positive results recorded in other elements of the survey. The concept of damaging source of energy perhaps was not explained clearly enough in the table and this led to confusion amongst the workgroup i.e. in the reflection survey 100% of respondents identified fatigue as a hazard but only 58% identified 'psychosocial' as a hazard despite fatigue being listed as an example of a psychosocial hazard in the table.

This indicates that the labelling and language used to describe workplace hazards need to be more carefully chosen to suit the vernacular of the cabin crew workgroup. It also highlights the importance of considering the different learning styles of workers and that conveying information about hazard identification via tables might not be the most effective approach to achieve the desired learning outcomes. As such, other methods such as classroom tutorials, online activities or more interactive communication techniques should be considered as a means to facilitate greater learning about energy sources and hazards amongst the cabin crew workgroup.

Feedback from the Reflection Survey also highlighted issues with the formatting of the Identi-fly booklet and suggested that improvements needed to be made to make the booklet quicker and easier for cabin crew to use. In particular, the feedback stressed the need for the content of the Identi-Fly booklet to take an online or App based checklist format so that it was more convenient for cabin crew to utilise. Results from the Reflection Survey can be seen in Table 2.

Hazard Identification Change Results

Overall the results produced by the Identi-Fly project provided greater insight into the hazard identification capabilities of the cabin crew workgroup. Data analysis of the two survey points identified clear knowledge gaps in the first Perceptions of Hazards survey results as well as predominately positive improvements in the workgroup's awareness of their workplace hazards in the second Reflection survey results. A comparison table of the hazard identification results across the use of the two surveys during the 14-week period can be viewed in Table 2.

Table 2. Table of Hazards Identified and Program Change

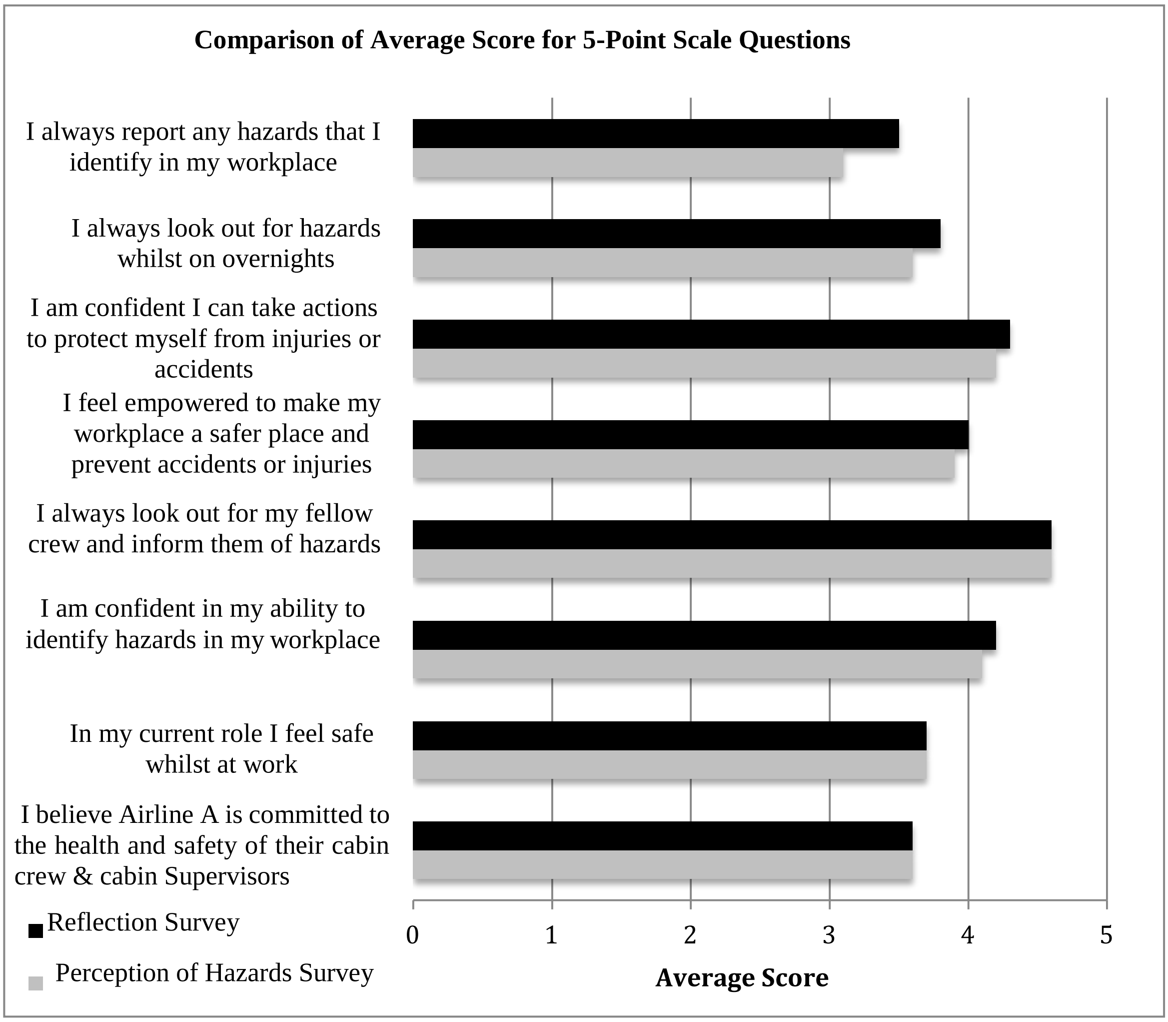
Hazard	Percentage of Hazard Identified in Survey 1: 'Perception of Hazards'	Percentage of Hazard Identified in Survey 2: 'Reflection Survey'	Change in percentage Identified
Electrical Appliances	15%	67%	+52%
UV/Sunlight	22%	54%	+32%
Falls from Height	55%	83%	+28%
Contaminated Crew Food or Passenger Meals	74%	88%	+14%
Dry Ice	52%	71%	+19%
Extreme cabin Temperatures	52%	71%	+19%
Portable Entertainment Devices	26%	42%	+16%
Aircraft Oven	77%	88%	+11%
Uniform/Personal Protective Equipment	30%	38%	+8%
Viruses	85%	92%	+7%
Hotels	48%	54%	+6%
Animals or Insect Bites	11%	16%	+5%
Motor Vehicles	37%	42%	+5%
Uneven, Oily or Slippery Surfaces	66%	71%	+5%
Excessive Noise	78%	83%	+5%
Fatigue	96%	100%	+4%
Acids	3.7%	4%	+3%
Bacteria from Lavatories or Waste Carts	85%	88%	+3%
Manual Handling	93%	96%	+3%
Moulds or Mildew	22%	25%	+3%
Turbulence	100%	100%	0
Hot Liquids	93%	92%	-1%
Power Tools	3.7%	0%	-3.7%
Forklifts	3.7%	0%	-3.7%
Cats & Dogs	3.7%	0%	-3.7%
Bodily Fluids	89%	71%	-18%

Table 3 shows the comparison of hazards identified according to an energy type. The workgroup showed an increase in hazard awareness across all energy types between survey one and survey two with thermal energy hazard awareness having the greatest increase.

Table 3. Comparison Table of Hazards Identified According to Energy Type

Type of Damaging Energy	Percentage of Hazard Identified in Survey 1: Perception of Hazards	Percentage of Hazard Identified in Survey 2: Reflection Survey	Change in percentage Identified
Thermal	51%	75%	+24%
Gravitational	61%	74%	+13%
Chemical	59%	68%	+9%
Acoustic	78%	83%	+5%
Psychosocial	96%	100%	+4%
Bio-Mechanical	93%	96%	+3%
Biological	59%	62%	+3%
Mechanical/Kinetic	37%	40%	+3%
Miscellaneous	15%	17%	+2%
Climatic/Natural	100%	100%	-

Figure 1. Graph Showing Pre and Post Measures for Safety Climate Questions



Safety Climate Results

The results from the use of the Identi-Fly booklet also indicated improvements in influencing the safety culture of the cabin crew workgroup with the results indicating an average improvement of between 1%- 4%. Only two questions resulted in no change at all, those related to feeling safe at work and the commitment of the airline to the health and safety of their cabin crew and cabin supervisors. The biggest changes in the data due to the introduction of the Identi-Fly booklet were regarding statements of reporting hazards (up 4%) and looking out for hazards on overnight stays (up 2%). A complete comparison between the first (pre) and second (post) survey results for the safety climate data can be viewed in Figure 1

Discussion

Overall the results produced by the Identi-Fly project provided greater insight into the hazard identification capabilities of the cabin crew work group. Further data analysis of the two surveys identified clear knowledge gaps in the first survey results as well as positive improvements in the work group's awareness of their workplace hazards in the second survey results. The cabin crew pre-task hazard assessment tool project was effective in its aim of developing, implementing and evaluating a tailored personal risk assessment tool for cabin crew. The project yielded some excellent results and successfully achieved its objective of improving the cabin crew work group's ability to identify hazards in their workplace. Results from the initial 'Perception of Hazards' survey uncovered that the cabin crew work group had a strong knowledge in the areas of turbulence, manual handling and fatigue-related hazards but was lacking awareness of gravitational, biological, thermal and electrical types of hazards. The development of the 'Identi-Fly' booklet to promote greater awareness in these areas appeared to close the gaps in knowledge amongst this work group. This was further supported by the data analysis of the second 'Reflection Survey' results which, when juxtaposed with the 'Perception of Hazards' survey results, outlined a significant improvement in the identification of nearly all hazard types and a particularly marked increase in work group's awareness of gravitational, thermal, chemical and acoustic hazards.

Within the limitations of the project's short 14 week timeframe, the Identi-Fly booklet also managed to make some slight improvements to the overall safety climate of the work group. Despite the project's initial expectations of having a greater impact on the work group's safety culture, there were still some positive indications that the vision of an 'interdependent' safety culture could be brought to fruition and established within the work group in the not too distant future.

This suggests that the booklet did have a positive impact by reducing complacency issues amongst the workgroup and prompted the cabin crew to give more thought about hazards outside of their normal aircraft work environment. It is important to note the short-time frame within the project meant that the booklet was only used for a 2-week period. Therefore, in order to extrapolate this data and gather an accurate indication of the impact that the 'Identi-Fly' booklet can have on influencing the safety culture of the workgroup, future studies would need to be conducted by the Airline to ascertain further quantitative data over a longer period of time.

Recommendations from Project Outcomes

It was evident from the summary data obtained from the pilot program from the use of Identi-Fly booklet that the tool made a significant impact on improving the work group's capabilities in a short period of time. However, in order to maintain positive learning changes within the work group and foster the desired safety outcomes, it is recommended that several further initiatives be implemented. These would include a recommendation that a comprehensive hazard awareness education program be implemented to support and underpin the introduction of the Identi-Fly booklet. Teaching cabin crew about the types of hazards in their workplace will provide them with a greater understanding of what they should be looking for when completing the Identi-Fly booklet. A hazard awareness program coupled with the use of the Identi-Fly booklet will also yield more beneficial results as cabin crew are empowered to take ownership of their own safety and possess a greater ability and improved confidence to implement control measures for hazards that they identify. An education program will also amplify the teachings of hazard awareness across various learning platforms to engage cabin crew. It will provide cabin crew with an opportunity to take what they learn in a classroom or online setting into the aircraft environment and apply their hazard identification skills in a practical and proactive way to protect themselves and others in the workplace.

Feedback from the work group surveyed emphasised the need for their personal risk assessment tool to be easily used within their time-poor environment. It was suggested that cabin crew could readily utilise digital devices within their work environment and use these devices for streamlining any work-related tasks. It is thus recommended that the airline develop an online form or App which cabin crew would use to quickly assess the Identi-Fly content straight from their personal devices and utilise the checklist for a briefing, on a turnaround or during their safety and security checks.

Summary

The program was designed to give an initial controlled data analysis opportunity for the short-term use of a personal risk assessment tool designed for airline cabin crew. The main limitation of the pilot program for the use of the Identi-Fly booklet was the short time frames and small sample size of the cabin crew surveyed. As such due consideration needs to be taken when applying these findings and recommendations to a wider cabin crew work group and it is recommended that in order to more accurately gauge the overall benefit of using such a tool that the tool becomes embedded as a long-term strategy to improve an airlines safety outcomes.

In order to determine the project's ability to achieve the airline's overall objectives, the project would need to allow for change to be measured over a greater extended period of time and the safety performance data of the cabin crew department to be ascertained across this extended period. Any long-term sustainability of this type of intervention project would also be dependent upon the continuous evaluation and auditing of the 'Identi-Fly' booklet to monitor its ongoing effectiveness within the workforce. This may mean that over time other strategies such as further education and hazard awareness programs are introduced to support the booklet. Furthermore, modifications may be required to change the format of the booklet, such as morphing it into an online digital format to allow for it to continuously move forward with the changes and evolution of the workforce and ensure that its objective of improving the hazard identification capabilities of the cabin crew workgroup is still achieved.

Overall this pilot project showed promising results for raising hazard awareness for the cabin crew work group, particularly around damaging energy types of hazards, as their knowledge and recognition of these types of hazards increased. The results from the use of the Identi-Fly booklet by the cabin crew work group also indicated improvements in influencing the safety culture of the cabin crew in respect of progression towards an independent safety culture. It is evident from the completion of the project that with the modifications and amendments recommended, the use of a Pre-task Hazard Assessment tool should be considered as an effective strategy in improving the hazard identification abilities and safety culture of the workforce. The Identi-Fly program should be considered a worthwhile investment by a cabin crew department due to its potential returns in supporting the group to achieve their desired work health and safety (WHS) objectives that include becoming incident and injury free in the future.

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Risk of Consuming Aluminum in Barbeque Cat-fish Prepared with Aluminum Foil

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Abstract

This study was undertaken to determine the risk of consuming aluminum in barbequed Catfish that had been wrapped in aluminum foil to protect the fish when being cooked. This research was conducted by oven drying raw and foil wrapped samples prior to laboratory analysis of aluminum concentrations in the Catfish. The method used was Atomic Absorption spectrophotometry, Wet digestion and subsequent Spectrophotometric process to determine the concentrations. Results obtained indicated leaching of aluminum from aluminum foil with a concentration of 0.007mg (kg) which indicates 18% addition of aluminum with reference to the original amount in the sample. Aluminum concentration in catfish was low and posed no health risk, although continuous and frequent consumption can lead to bioaccumulation. It was therefore recommended that caution be taken in consumption of catfish as aluminum leaching up to 18% was observed.

Key Words. Risks. Barbeque Cat-fish, Aluminum foil. Leaching.

1. Introduction

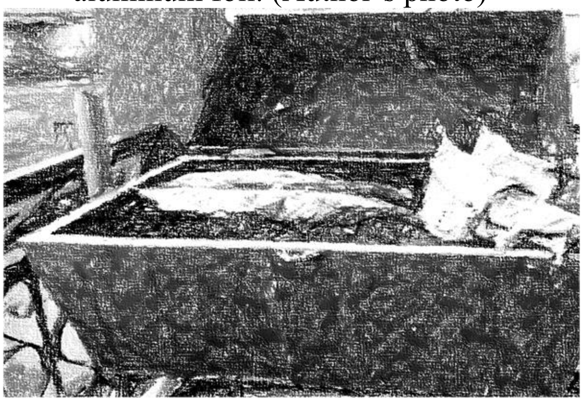
Aluminum is a silvery white metal belonging to the boron group of chemical elements and has an atomic number of 13. Its density is 2.70 g/cm^3, non-toxic and with good machinable properties. The electrical conductivity of aluminum is 60%, hence it is used extensively for electrical transmission lines. Because of aluminum's attractive properties, it has a variety of industrial applications. (Joshi *et al.*, 2003; Sadattin, 2006; Rajwanshi *et al*., 1997 and Ranau *et al.*, 2001).

Its attractive chemical and physical properties make it ideal for using in the manufacturing of drugs, cosmetics, food additives and utensils (Ranau, Oehlenschlager, and Steinhart, 2001). It has significant hazardous effects on humans due to its pervasive nature. Effects in use of aluminum utensil for cooking are reported to result in aluminum ingestion (Semwal *et al.*, 2006). Major sources of dietary intake include synthetically added aluminum (that is, grain products, processed cheese and salt) and naturally occurring high aluminum dosages (that is on tea, herbs and spices). Aluminum erosion from utensils is more likely a minor or inconsistent source. Meat and fish are commonly wrapped in aluminum foil prior to oven cooking. Aluminum may leach out of the foil and contaminate the food resulting from different stimulants and high temperatures (Ojha, and Sharma, 2007; Ranau *et al.*, 2001). Aluminum is abundant in the earth's crust and is a natural component of drinking water, food and many manufactured materials (Thorsen, Hasan and Hubertus, 2011). It is redistributed or moved by natural and human activities (Khalil and Seliem, 2014).

High consumption of Aluminum can cause cumulative chronic health effects **(**Semwal *et al.*, 2006; Berlyne *et al*., 1970 and Meiri *et al.*, 1993**)**. Aluminum ion can inhibit different metabolic processes in human body by replacing other essential ions i.e. iron, magnesium, calcium, phosphorus, fluoride.

Currently in Nigeria, it is a common practice to wrap meat items in Aluminum foil for baking and grilling. Aluminum is found to leach out from the foil due to stimulants; particularly in distilled water as well as in acidic and alkaline media. A tolerable daily intake (TDI) for aluminum of 1mg/kg body weight per day has been established by an international committee of experts under the auspices of the World Health Organization (WHO) and the Food and Agricultural Organization (FAO) of the United Nations (WHO, 2001; Jack, 2005). This exposure comes mainly from cooking food wrapped in aluminum foil. It was suggested in many studies that cooking food in Aluminum foil develops Al toxicity causing many specific diseases **(**Rehmani *et al.,* 2010; Carson, 2000). For this reason, food cooked within aluminum foil may contain a high risk for ill health and an addition to other aluminum sources. Hence this research investigated the leaching levels of aluminum from aluminum foil used in making barbeque catfish as shown in figure 1 below.

Fig. 1. Barbeque catfish wrapped with aluminum foil. (Author's photo)



2. Food Contamination

Food contaminant can be biological, chemical or physical in nature, with the former being more common. These contaminants have several routes throughout the supply chain to enter and make a food product unfit for consumption (Malik, 2016; WHO, 2017; Australia Institute for Food Safety (AIFS), 2019). and Fukuda, 2015).

3. Aluminum foil in Food Preparation

Food wrapped in aluminum foil may contain a high risk for ill health. Catfish contains vitamin D, low levels of omega-3 fatty acid and high proportion of omega-6 fatty acids (Jordan, 2015). The major process for catfish preparation in Nigeria is to wrapped in aluminum foil together with marinating ingredients and grilling in high heat till cooked (barbequed). This is currently considered the most common practice for which which farmed catfish are used, especially in celebration and festive periods.

It was observed that the aluminum content of grilled fillets was higher than those of baked fillets. Aluminum migration from utensils can be regulated by grilling duration, rising temperature due to heating, composition, food pH value, and presence of any other substances (such as organic acids and salt) (Shupping, 1996)**.**

4. Detriment of Excess Aluminum Intake on Health

Aluminum can interact with transition metals; in particular, the interaction with iron and copper enhances the production of reactive oxygen species by these two redox-active metal ions, leading to the exacerbation of cell oxidative stress and neuronal cell death (Becaria, Bondy and Campbell, 2003; Peto, 2010; Percy *et al.,* 2011).

Studies of environmental toxicology in recent years have revealed the symptoms such as diminished intellectual function / forgetfulness, inability to concentrate, speech and language impairment, personality changes, altered mood, depression, dementia, Visual and/or auditory hallucinations, Osteomalacia with fracturing, weakness, fatigue, mainly related to microcytic anaemia and Epileptic seizures. in humans, animals and plant roots (Guido et al., 2013; Sedman *et al*., 1985).

5. Methodology

The detection of leaching levels of aluminum from aluminum foil used in making barbeque catfish was conducted using three step.

a. Sample Collection

The grab method of sample collection was used in the collection of samples and stored before use. Two freshly caught specimens were obtained from the market and used for the detection of aluminum levels and leaching in barbeque catfish prepared with aluminum foil.

b. Preparation of Sample

Two specimens of catfishes were analyzed to determine the extent of aluminum leaching into the catfish cooked using a barbecue. In determining the extent of aluminum leaching, one specimen was marinated and wrapped in aluminum foil while the other was marinated and kept aside as a control prior to oven drying and analysis. The samples were placed weighed into crucibles and ashed in the muffle furnace at 600ºC for one hour. After oven drying, each specimen was ground on a mortar and representative samples taken for analysis.

c. Digestion of Sample and Analysis

The organic matter content of the organisms were destroyed by wet digestion in order to isolate the trace metal from the food samples. One gram of each dried sample was weighed into a 100ml beaker and 20ml of digestion solution added. A Digestion Solution of 1:1, mixture of Nitric acid and Sulphuric acid was filtered into a 50ml volumetric flask and then analyzed for Aluminum using atomic absorption spectrophotometry (AAS).

6. Results and Discussions

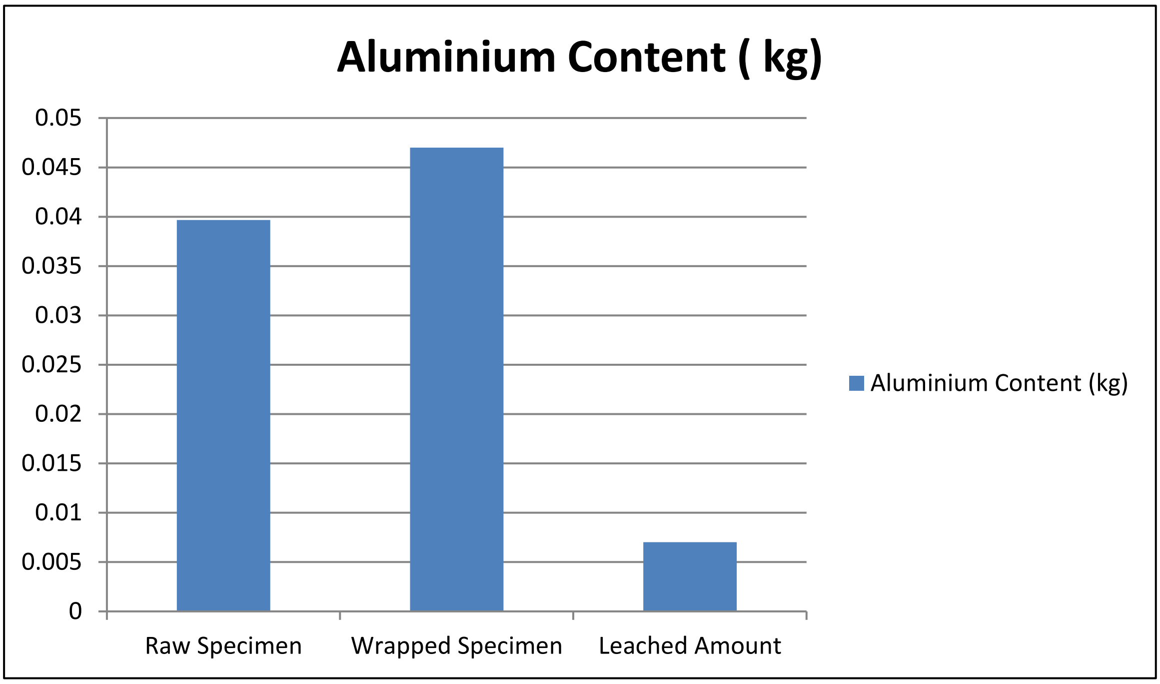
Table 1: Results of aluminum concentration of three samples of catfish

Catfish	S1	S2	S3	Mean	Variance	Standard Deviation
Raw Specimen (kg)	0.04	0.038	0.041	0.039667	2.33333E-06	0.0015275
Foil Wrapped Specimen (kg)	0.046	0.048	0.047	0.047	0.000001	0.001
Amount of Leaching(kg)	0.006	0.01	0.006	0.007333	5.33333E-06	0.0023094
Percentage of Leaching	15	26.31579	14.63415	18.64998	44.10695443	6.6413067

Table 2: Average result of aluminum concentration in three tests of catfish

Catfish (mg or kg)	**Mean**	**Variance**	**Standard Deviation**
Raw Specimen	0.039667	2.33333×10^{-06}	0.0015275
Foil Wrapped specimen	0.047	0.000001	0.001
Amount of Leaching	0.007333	5.33333×10^{-06}	0.0023094
Percentage of Leaching	18%	44%	6.6413067

Fig. 2: Aluminum content in Raw Specimen against Specimen prepared in aluminum foil.



7. Discussion of Result

Most times, humans consume far more aluminum contents than the body can process and excrete.

Result from laboratory analysis in table one reveals an increase in aluminum concentration when the catfish was wrapped in aluminum and heated at 600°Cfor a period of one hour. Similar outcomes have been reported by Ranau *et al*., (2001) when three different species of fishes were wrapped with aluminum foil to ascertain possibilities of aluminum leaching. It was revealed that there were possibilities of aluminum leaching related to the temperature and time cooked for. Result obtained from the above study clearly indicated an increase in aluminum concentration from 0.4–0.47 mg or kg (that is an increase of 0.07mg or kg). This possibility of leaching can be pointed to the temperature of heating, style of preparation that includes (body cuts made and grilling style) and generation environmental conditions which aluminum foil is subjected to.

8. Conclusions and Recommendations

Conclusions

Result clearly shows aluminum migration into catfish in the amount of 0.07mg or kg. The consumption of catfish wrapped in aluminum foil and prepared for an hour possess no major health risk as the amount of migration is below the allowable daily intake set by F.A.O and WHO. Consumers should know that aluminum concentration in catfish is low. This is due to the fact that it is cultured in a controlled environment with scientifically and quality produced feeds. Other factors, including temperature and cooking time, may contribute to excessive leaching.

Recommendations

Based on acquired results, comparison with permissible standards and conclusions drawn, the following recommendations are made.

I. Catfish prepared with aluminum foil should be taken with caution as there are possibilities of aluminum leaching.
II. Catfish subjected to controlled environment through horticulture should be consumed as there possess negligible amount of aluminum concentration in comparison to those obtained from environments subjected to heavy metals contamination.
III. In view of eliminating aluminum intake by humans, aluminum foil should only be used for packaging purposes.

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An Abridged History of Anthropometry

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Abstract

Anthropometry is a scientific set of principles that are used to accurately measure the human body in terms of lengths, breadths, circumference, how the body moves as well as the angles between planes. Humans have an exceptionally long history of studying the body and making objects that fit the body rather than trying to fit a body to the object. Anthropometric principles have been used in the design of the earliest tools, classical art works and even fortune telling. In recent times these measurements are used in the design and creation of almost every aspect of modern life. Anthropometry has been used in the investigation and justification of many things, some lacking scientific credibility, but most furthering scientific evidence-based research into diverse fields including criminal investigations, anthropology, as well as health and well-being studies.

Keywords: Anthropometry. Anthropology. History. Classic. Modern.

Introduction

Anthropometry in general terms is a collection of methods for measuring and assessing the human body that is used widely in art, engineering and design (Adams, 2019; Biology Dictionary, 2017; Bridger, 2003; Bridger, 2017; Encyclopaedia Britannica, 2020; Hedge, 2013; Middlesworth, 2020; New World Encyclopedia, 2016; Nowak, 2001; Oxford Reference, 2020; Patel, 2018; Stack, 2016).

Anthropometric measures include linear, angular, circumferential, and force measurements, assessing length, breadth, height, angles between body planes, volumetric data, as well as how the body moves (Adams, 2019; Biology Dictionary, 2017; Bridger, 2003; Bridger, 2017; Hedge, 2013; Middlesworth, 2020; NASA, n.d.; New World Encyclopedia, 2016; Nowak, 2001; Patel, 2018; Stack, 2016).

These body measurements are now used in every aspect of design where the human form is involved, from clothing, design of controls, architecture, and even NASA capsules (Designing Buildings, 2020; Lewis, 2011; Middlesworth, 2020; NASA, n.d.; Nowak, 2001).

Anthropometry came from the science of anthropology, growing directly from the desire to understand the human body, its origins, and adaptability, meaning scientists needed a way to measure and communicate findings to others in an accurate and meaningful manner (Institute of Industrial & Systems Engineers, n.d.; Nowak, 2001).

Methodology

A systematic review of English language articles was performed in June 2020, using Google Scholar. The literature search was limited to English language articles published between the years 2000 and 2020. Key search words used were “history”, “of”, “human”, and “anthropometry”. A total of 27,000 articles were obtained from this search. The search parameters were refined to remove irrelevant results, bringing the total results down to about 9,300. Results beyond the first hundred relevant results were excluded. After reading abstracts to further exclude irrelevant articles, non-English language articles, removing duplicates and studies where the full article could not be accessed, a further 93 were removed. A total of 7 relevant articles were used for this review.

A second search was conducted through the Curtin Library Catalogue search engine with the same keywords returning 6,213 results. Again, limiting to the first hundred results, and excluding irrelevant articles, duplicates, non-English articles, and non-full articles, yielded a further 4 articles for review. A third search was conducted with the same keywords and time-frame using Google search engine, returning 1,490,000 results. Excluding irrelevant, Non-English results, and material of low quality, while limiting to the first hundred results, yielded another 19 articles.

A total of 31 articles are cited in this literature review. The articles found discuss the history and development of anthropometrics. There has been a great quantity of research using anthropometrics in various settings, but less so on how the science of anthropometrics came into being.

Ancient History

Stone Age tools are the earliest example of anthropometrics as applied to a designed artifact however no evidence exists for any scientific method of measurement being used in their design (Lewis, 2011).

Physiognomy, a precursor form of anthropometry dates back to the Warring States period of ancient China (770 to 221 B.C.), although it did use body measurements, it was used solely for fortune telling, with the most famous example of this is being, Ma Yi, a fortune teller who lived during the Northern Song Dynasty (960 to 1127 A.D.) (Shi, 2015).
Anthropometry, specifically static anthropometry, or the study of unmoving body part measurements can arguably be dated to classical civilizations such as the Romans and Greeks (Albrizio, 2007; Biology Dictionary, 2017; Cuff, n.d.; Stack, 2016). A fifth century B.C., Greek sculptor, Polykleitos, is recorded as having written a work on human proportions and anatomy, highlighting anthropometric studies started with the arts (Albrizio, 2007; Kilgore, 2012).

Recent History

Leonardo DaVinci began researching the area of anthropometrics around 1487, although it was not known by this name (Aeronautics Guide, n.d.; Biology Dictionary, 2017; Kilgore, 2012). He was continuing the traditions of classical artists of accurately measuring subjects for the purposes of the creation of art (Aeronautics Guide, n.d.; Biology Dictionary, 2017; Kilgore, 2012). DaVinci was a forerunner in human based design, with many of his designs based around the human, instead of trying to fit a human to his design (Aeronautics Guide, n.d.; Kilgore, 2012). DaVinci's Vitruvian standard, as typified by the "Vitruvian Man", although it does deviate from modern anthropometric data, is within one standard deviation of present means and so, could be used as a guide for modern health professionals in ergonomic design (Kilgore, 2012).

The term anthropometry was likely first used by naturalist Johann Sigismund Elsholtz, in his 1654 publication "De mutua membrorum proportione", a short work on the proportions of the body (Albrizio, 2007). Anthropometrics started to become an established science in the West in the early 1700s, with records being kept for measures such as height, weight, and birth weight, on portions of populations from many nations, although at the time they were used mainly as an indicator for assessing socio-economic well-being (Cuff, n.d.).

In the mid-eighteenth century a person's height was a commonly used metric to classify them into different units when they entered military service, while also being used in the United States to track and measure the characteristics of slaves (Cuff, n.d.). In Britain, fear of "degeneration" in men and their potential as a fighting force would result in large-scale anthropometric surveys to assess the true situation (Cuff, n.d.).

Curiosity about anthropometric measurements by scientists in the eighteenth century had started to spawn the creation of textbooks on human growth, which would go on to spark concern around growth patterns in different socio-economic groups (Cuff, n.d.). By the nineteenth century there was a growing outrage, partly caused by the children depicted in Charles Dickens' Oliver Twist, resulting in an anthropometrically evidenced approach in medicine to aid the poor (Cuff, n.d.). In the nineteenth century there was growing demand from anthropological societies for quantitative data on human measurement in order to further various fields of research from archaeological investigation, to studies into hereditary traits, and evolution (Albrizio, 2007; Institute of Industrial & Systems Engineers, n.d.; New World Encyclopaedia, 2016).

Industrial engineers, Frank & Lillian Gilbreth, while trying to reduce human error in medicine, developed a concept called the “challenge-response” system, where a person calls out a word and a second person repeats it (for example, a surgeon calling out ‘scalpel’ and a nurse repeating ‘scalpel’ as they hand a scalpel to the surgeon), a system that would become standard practice in surgery and among pilots (Aeronautics Guide, n.d.). Though this system was not directly a component of anthropometry at the time, the work-study method, and principles they developed would further the study of anthropometrics (Aeronautics Guide, n. d.).

During the Victorian era, with a boom in industrialisation, factory owners wished to increase productivity and factory output, Frederick Winslow Taylor saw an opportunity for scientific study to improve conditions (Bridger, 2003; Bridger, 2017; Stack, 2016). Building on the work study method developed by the Gilbreths, Taylor developed a principle later called Taylorism, that advocated for fitting the design of the machine to the person operating it, instead of trying to find a person that would fit the requirements of the machine, another step forward towards modern anthropometrics (Aeronautics Guide, n.d.; Bridger, 2003; Bridger, 2017; Institute of Industrial & Systems Engineers, n.d.; Stack, 2016).

In the nineteenth century, Alphonse Bertillon, the founder of the Society of Anthropology Paris, dissatisfied with current identification techniques, used the principles of anthropometry to develop a scientific system of identification for the French police to more accurately identify suspects and also created a system to reliably store and retrieve that information based on anthropometry (Anthrotech, 2019; Biology Dictionary, 2017; New World Encyclopedia, 2016; Patel, 2018; Piazza, 2016). The system furthered anthropometry and became known as “Bertillonnage”, Bertillon himself would later come to be viewed as the founder of modern anthropometry (Biology Dictionary, 2017; Patel, 2018; Piazza, 2016).

Modern

In the 1920s, Ales Hrdlicka, a physical anthropologist, summarised the purposes for taking anthropometric statements as being for industrial design, artistic, military, and medical purposes, also to be used for the detection and correction of bodily defects, as well as for forensic purposes (Institute of Industrial & Systems Engineers, n.d.).

Beginning in the early twentieth century, longitudinal population surveys were established in North America and Europe; in some cases, they were aimed at the generation of growth standards and others to evaluate the effect of social class differences (Cuff, n.d.; Harris, 2019). These studies are viewed as transitional steps from historical to contemporary anthropometrics (Cuff, n.d.).

With the advent of World War 2, and new complex machinery in the form of aircraft and tanks, designers needed to fit the machine to the human to ensure efficiency of purpose and to minimise user error. (Aeronautics Guide, n.d.; Anthrotech, 2019; Lewis, 2011; Stack, 2016). Pilots and drivers needed to be able to fit into their machines and easily operate controls with the minimum of effort or error, so engineers used anthropometric data to create designs that fit the average pilot and driver, furthering the field of anthropometric design (Aeronautics Guide, n.d.; Anthrotech, 2019; Institute of Industrial & Systems Engineers, n.d.; Lewis, 2011; Reed, 2020; Stack, 2016).

Published studies in the 1960s and 1970s by Le Roy Ladurie on nineteenth century French soldiers detailing their height and socio-economic characteristics are recognized as the first in the spirit of modern historical anthropometrics (Cuff, n.d.; Komlos, 2009).

Since the middle of the twentieth century, anthropometric studies have been used for a variety of purposes, such as, refining growth standards, monitoring nutrition status, and to evaluate economic development (Cuff, n.d.; Harris, 2009; Harris, 2019; Institute of Industrial & Systems Engineers, n.d.; Komlos, 2009; Oxford Reference, 2020; Reed, 2020).

During the Cold War, research into anthropometrics flourished when the U.S. Department of Defence expanded, creating new laboratories and facilities, each needed to be as efficient as they could be made, and to further ergonomic research into military machines and equipment (Aeronautics Guide, n.d.). The scope of this research initially was focussed on small equipment and workstations, expanding to larger scales and whole systems processes, later coming to include civilian equipment, processes, and industries (Aeronautics Guide, n.d.).

Body Mass Index, a measure calculated from height and weight, is included in modern anthropometric measures and is often used in nutritional and exercise studies, as well as a general measure of health of a population, although how it is interpreted and its validity in certain contexts is contested (Rolland-Cachera, 2020).

Anthropometric studies have also been used to describe and understand human adaption and adaptability to their environment, as well as to develop a framework for understanding evolutionary contexts (Encyclopaedia Britannica, 2020; Institute of Industrial & Systems Engineers, n.d.; Ulijaszek, 2010).

Modern anthropometric principles and practices are used in the design processes of many things, such as building, vehicle, and furniture, and clothing design, taking into account both static and dynamic measured data, to ensure the end user's comfort and these ease of usability of the designed item (Anthrotech, 2019; Bridger, 2003; Bridger, 2017; Designing Buildings, 2020; New World Encyclopedia, 2016; Patel, 2018; Stack, 2016). Principles of anthropometry have influenced the design of many things, not only in how they are operated, but also in the manner they are assembled, and how they are worked on should they need maintenance (Aeronautics Guide, n.d.; New World Encyclopedia, 2016).

Anthropometric data can be divided into percentiles with the 5th and 95th percentiles being the most important and commonly used in design (Bridger, 2003; Bridger, 2017; Hedge, 2013; Institute of Industrial & Systems Engineers, n.d.; Lewis, 2011; NASA, n.d.; Nowak, 2001). The 5th to 95th percentiles are used for ergonomic design to accommodate 90% of the population, including those outside this range doesn't bring about any further design benefits and may detract from functionality (Bridger, 2003; Bridger, 2017; Hedge, 2013; Institute of Industrial & Systems Engineers, n.d.; NASA, n.d.).

Although appearing to be the median and most useful measurement, it is not recommended to just use the 50th percentile data as this will only suit a smaller proportion of the population than the 5th to 95th range will (Bridger, 2003; Bridger, 2017; NASA, n.d.; Stack, 2016).

For design considerations it is important to consider the demographics of different populations and genders, for instance Male Caucasian populations generally have larger measurements than Female Asian populations do (Hedge, 2013; Institute of Industrial & Systems Engineers, n.d.; NASA, n.d.; Nowak, 2001; Stack, 2016). Two important examples of this would be using the 5th percentile of Asian Females to determine the maximum distance a control panel can be away from a user for it to be operated comfortably, and the 95th percentiles of Caucasian Males to determine upper limits on comfortable seat sizes (NASA, n.d.; Nowak, 2001).

Aggregate measurements are an important aspect of anthropometric data when used for ergonomic design to account for individual variability, this is because an individual may be in a certain percentile for one body dimension, such as the 5th, but be in the 50th for another dimension (Bridger, 2003; Bridger, 2017; Institute of Industrial & Systems Engineers, n.d.; Nowak, 2001).

A minimum sample size of 200 individuals is recommended by the World Health Organisation for anthropometric data when it is used for reference standards (Bridger, 2003; Bridger, 2017). Children, adults, and those in wheelchairs are all routinely considered in the design process with anthropometric data used individually and considered in whole of purpose design (Bridger, 2003; Bridger, 2017; Designing Buildings, 2020; New World Encyclopaedia, 2016; Stack, 2016).

Anthropometrics have been used to develop somatotypes that describe human physiques, these fall into three main types, Endomorph, Ectomorph, and Mesomorph (Biology Dictionary, 2017). Endomorphs have a tall, thin body type, Ectomorphs are shorter than Endomorphs, have linear body shape and thin muscles, while Mesomorphs have a rectangular shape and are broader than the other types (Biology Dictionary, 2017).

Controversial Use

In the eighteenth century as interest in human biological variety was increasing and as Europeans came into contact with a greater range of peoples and cultures. Anthropometry was used to justify theories of humanity that were based on racial prejudices of the time and were not evidence based, with one such theory positing that there were four “subdivisions" of humans with their own unique traits, this theory was later overturned through empirical testing (Anthrotech, 2019; Encyclopaedia Britannica, 2020; Ulijaszek, 2010; Smith, 2019).

In the late Victorian era, Francis Galton started the eugenics movement, an idea that promoted the “fitness” of one trait over another, and through this hoped to “improve” the genetic composition of the human race through selective breeding (Adams, 2019; Gillham, 2001; Smith, 2019). Galton used anthropometric principles to justify the theory of eugenics (Adams, 2019; Gillham, 2001; Smith, 2019).

Anthropology and anthropometrics have been used to justify many theories that have a less than scientific basis, one such theory was Phrenology, the study of the head and facial characteristics to determine personality traits and the predisposition for criminality (Adams, 2019; Anthrotech, 2019; Biology Dictionary, 2017; Patel, 2018).

Conclusions

Anthropometry has roots dating back into prehistory with signs that the earliest stone tools were designed to fit the hand that wielded them. Later anthropometric type studies were conducted in ancient cultures for the accurate depiction of the human form in art works, as well as to be used to predict a person’s fortunes. More recently, anthropologists started to use anthropometric principles to measure populations, to track not only their suitability for armed services, but also to track growth rates and to get an idea of their nutrition. Anthropometry, through the efforts of many pioneering scientists expanded into many fields, including industrial design and criminal investigation, showing the potential it held for improving processes. In modern times, with anthropometry having been well established and shown its utility, it is used in the design processes of every aspect of modern life while also being used to study populations’ health and well-being.

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Planned Intervention of Behaviour-Based Safety (BBS) Helps Organizations Improve Their Safety Time Arithmetic

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Abstract

This article describes the value of an intervention of behaviour-based safety (BBS) that can increase the safety time of organizations for collective control of incidents and promote outcomes of positive safety culture as evidenced in research, field based interventions, experiences and practice. The results revealed that safety time arithmetic in organizations could be improved to obtain positive safety culture outcomes to save life and business in companies. The pain of daily fatalities at sites should become a motivational force for committed corporate leaders to achieve zero harm, zero at-risk behaviours, positive safety actions with every effort and cost, prepare their men and women at sites for daily observation and spot-correction of all at-risk behaviours and other hazards, and continue sharing positive safety actions throughout the organization.

Keywords. Organizations. BBS intervention. Safety-time. Incident. Culture. India.

Introduction

Like a health risk such as the Corona virus, a single person, if not controlled, can shake a country badly. Similarly a single safety at-risk behaviour, like a procedural violation, can destroy a business organization. Indian industry with a large diversified workforce and work cultures, has on an average 30 percent of at-risk/harm behaviours, resulting in daily work related fatalities and disabilities. Unsafe acts have been identified as a major factor of incidents and accidents (Xu, Zou & Luo, 2018). In behaviour-based safety (BBS), it is believed/ practiced that 5 minutes observation-cum-spot-correction of unsafe/at-risk behaviours daily by the company employees is considered as:

5 minutes used in saving a life;
5 minutes of sharing goodness;
5 minutes practice in humanity;
5 minutes of brotherhood;
5 minutes of affection;
5 minutes of caring;
5 minutes of safety dialogue;
5 minutes of empathy;
5 minutes safety involvement;
5 minutes of zero incident;
5 minutes of zero-harm culture.

BBS is an approach to save employees from the traumas of injuries and incidents in industry. Like a child feels safe with their mother, the person observed feels safe with the big brother safety (BBS) observers at sites/plants. True BBS observers don't differentiate amongst people while saving their life from at-risk behaviours. They don't differentiate in observing people due to their education, income, designation or age. True observers save people equally. Equality in saving people from even smallest injuries is valued by a true and active observer. BBS is a worldwide application of behavioural science to save life and business from incidents.

Methodology

This paper is an interdisciplinary intervention of behavioral science, management and industrial safety disciplines that are part of an ongoing national longitudinal action survey in India. Thematic data analysis was used to reflect the findings. The BBS program as part of this action survey was implemented in diverse locations in India for employees of multinational companies that were trained as BBS mentors and observers during the years 2018-20. This program included the concept and process of BBS, plant visits for observation and correction of at-risk behaviors, developing road map for implementation of BBS, developing training module for imparting training to all employees, formation and functions of

BBS steering team. More than 5000 training participants included managers, heads of departments, contractors, safety officers and contractors' staff belonging to the public and private industrial sectors such as chemicals, construction, gas, power, and steel across geographic locations. See figure 1.

Results and Findings

The following findings and themes emerged from the data collected as described in the methodology.

1. Safety behaviours can be defined, observed, corrected on the spot, measured, implemented, and sustained (Kaila, 2018). BBS implementation is likely to collapse if these aspects are missed.
2. Lack of understanding the BBS concept/process is adversely proportional to its implementation by people at sites. Those who understand implement it and vice versa. Hence, it becomes crucial for each Head of Department to ensure this repeatedly for creating a true interdependent safety culture. In a Malaysian Oil and Gas Companies' case study (Ismail et al., 2011), it was found that lack of leadership was the primary cause of ineffective implementation of BBS. The role of top management is important to make safety programs successful and sustainable. Possibly, the government safety rules and industry bodies should make BBS implementation mandatory for every organization in the interest of people's life and company business.
3. A reactive/ blame /punishment safety culture will not allow BBS culture to survive, as a reactive culture is inherently negative and a BBS culture is positive and supportive.
4. It would be very important and helpful to fix and follow the strict timelines strategically to control the existing at-risk behaviours identified with immediate effect by everyone.
5. BBS is essentially a planned/Informed organizational intervention initiated by the company top management along with a behavioural scientist for its implementation.

daily observation of at-risk behaviours and

6. The level of informed behavioural risk increased after BBS was rolled out at sites, because the behavioural risk monitoring increased, not only by the safety department, but also by the BBS observers of each department and work area.
7. Safety Time. It is important that the heads of departments ensure their colleagues are giving safety time of 5 minutes every day. The Chief Executive Officer (CEO) has to announce this message on the BBS launch day. Being a safety caretaker, empathizing concern for life without injury is what is called suraksha seva parmo dharam which means safety service is superb religiousness. Safety time gets increased multifold when everyone gives 5 minutes. It is of paramount importance that organizations improve their safety time arithmetic by increasing BBS trained observers. More safety time leads to less unwanted incidents at site. More parameters can be identified in order to improve and sustain organizational safety time arithmetic, such as reward and recognition to observers. Great safety leaders spend time out where their employees are. It's where the real work gets done, the shop floor (Mark, 2019).

Clarifications on BBS

Q: ***What is BBS implementation?***

A: Involving everyone in actively correction of behaviour is BBS implementation. An employee who does an at-risk behaviour is convinced subconsciously that it is safe as he or she has been engaged in working this way for a long time. When everyone around observes and convinces him/her to correct it, the correction power serves as a group influence and dynamic force for him/her to get corrected. Finally he/ she becomes conscious of this behaviour and keeps doing correction on his/her own.

Q: ***We started this exercise in the month of June, every month tracking is done. The graph is showing uneven trend. Seniors are asking why it is not in decreasing trend. Please give your comment on it.***

A: People need to be communicated about *their spot-correction* through mass-communications, public address system (PAS) as well as tool box talk (TBT) by their heads of departments. This is part of the BBS action plan. You will see the trend changes on implementing this aspect.

*Q: **How to implement BBS in a company?***
A: Behaviour-based Safety commences with the safety professional and others performing observations on the CEO to check that the company CEO is ensuring that the workplace, all work processes, all equipment and products used by employees is fit for purpose and safe. The employer / CEO controls the finances and makes the decisions on how this money is spent. Without a safe workplace and work processes provided by the employer or CEO, employees will be unable to work safely and work related injuries, ill health and deaths will continue to occur, no matter how much employees are trained to work in unsafe situations or with unsafe equipment or products. Handholding companies to reduce injuries through series of systematic training in BBS implementation plan spanning a year or two and get them BBS certified is also recommended.

*Q: **How to collect BBS data? How to approach observee for correcting at risk behaviour for your group?***
A: refer to the following two tables, A and B.

A. How to approach an observee for correcting at risk behaviour for your group

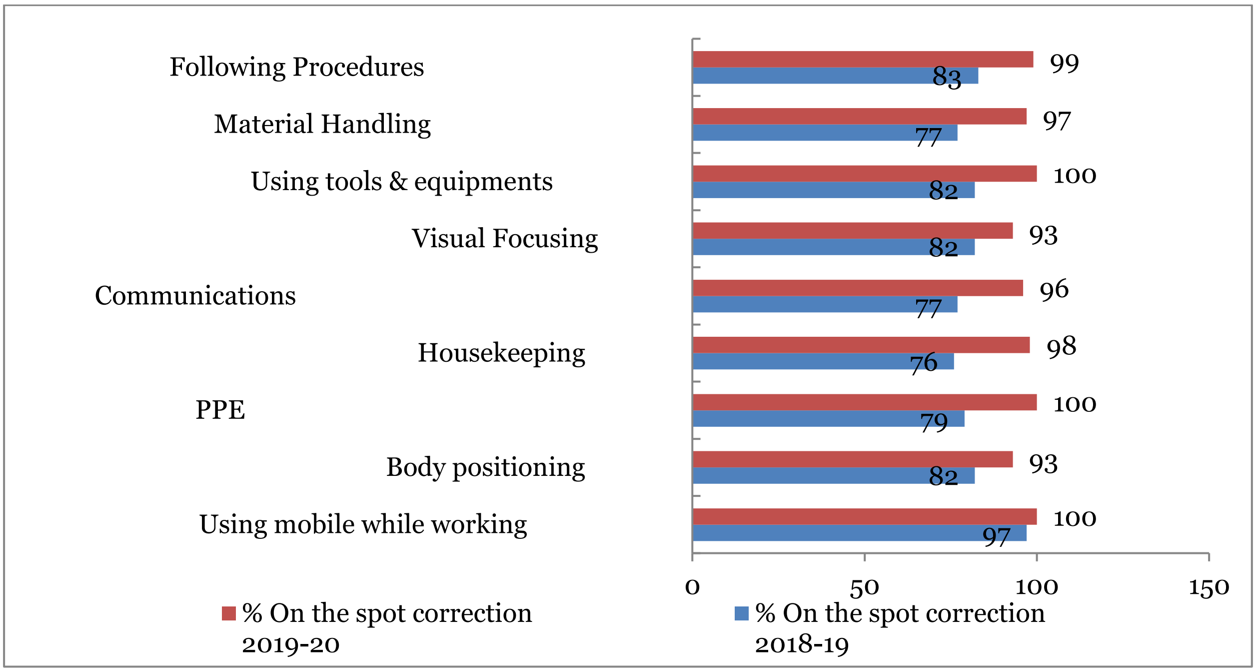
Sl. No.	11Ps	Description
1	Parikarma: observation round	Take an observation round of your unit/plant and observe your own group at any one site for 5- 10 Minutes on daily basis.
2	Prashan: question	If you find any one at risk, Put a question to an observe whether he is safe
3	Prashansa: praise	If you find someone always demonstrating safe behaviour, please praise for his safe behaviours to reinforce.
4	Parivartan: change	If you find someone at risk behaviour, try to correct him by positive feedback and convert his unsafe behaviours to safe.
5	Prashiksan: educate	If you feel someone at risk behaviour due to lack of training, then please educate/re-train him for his unsafe behaviours.
6	Pratigya: oath	After counselling, please take an oath/**promise** from him that he will not repeat unsafe behaviours in future.
7	Prachar: spread	Ask an observee to observe another co-worker and do spot correction. This will help in involving 100% employee and strengthen internal implementation.
8	Prarthana: request	Behave Like big brother not like Boss, than only observee will be in acceptance mode
9	Purushkar: reward	Develop a system of Spot-reward and recognition to observee to motivate them
10	Promise:	Take a promise from observee that, observee would also observe the observer, so that he will feel empowered
11	Pursue:	It need continuous effort for make BBS success, so inform observee that others will also observe you if you repeat at-risk behaviours

A. Suppose you have 10 persons in one group and want to observe that group while working on the 10 parameters below.

Sl. No.	Behaviour	How to collect data	Safe Behaviour	At-Risk Behaviour	Spot Correction
1	Use of PPE's	Suppose 8 person are perfect but one is not using a chin belt + one found without safety shoe. Spot correction done to belt person, but unable to correct person not wearing safety shoes.	8	2	1
2	Housekeeping	If you are observing two spots and find one good housekeeping but one unsafe condition and not able to correct immediately	1	1	0
3	Using tools/Equipment	If only 4 out of 10 are used while you were observing+ found two person using correct tools, but other two were either using wrong tools or defective tools and you are able to correct both of them	2	2	2
4	Body positioning	Out of 10 workers during 10 minute of observation, found 7 with perfect position, but three of them with at-risky behaviour and corrected all of them	7	3	3
5	Material handling	If a material is being handled by three person in a wrong manner then it will be three if not able to correct them	0	3	0
6	Communication	If two persons communicating regarding job and if it is correct	2	0	0
7	Following procedures	If SOP is followed, but work permit was not taken. You are able to stop the job and convince them to take a work permit	1	1	1
8	Visual focusing	If out of 10, three are found not alert while working, but you are able to do spot correction	7	3	3
9	Using mobile while working	During 10 minute of observation, you found 5 persons used mobile. Three of them moved out of workplace and used mobile, but two of them started speaking while working, but you could correct one of them	3	2	1
10	Road Safety behaviours	While coming to duty or while going home, check if all of them taking care of road safety. If three found at-risk, but able to correct one of them	7	3	1

Figure 1. Example picture of a BBS training workshop of employees

Figure 2. Uflex Chemicals BBS Performance 2018-19 v/s 2019-20



All behaviours are spot-correctable, so let all observers emphasize on the spot-correction of all at-risk behaviours. They need to be trained during mass-communications and to be told regularly for observation/spot-correction daily.

Experiences and outcomes of BBS

Indian Multinationals Jindal Steel Plant

Behaviour Based Safety programs are currently being used as an effective techniques in safety programs.

Behaviour Based Safety programs use positive reinforcement to prevent work related injuries and illness. Behaviour Based Safety program directly involves the employer and employees in accident prevention by their involvement and participation in workplace safety. Implementation of BBS changes the approach of individual, as *I am responsible for my own safety as- I follow the rules because I want to be safe*

Bhilai Steel Plant

At the Bhilai Steel plant for sustaining the BBS culture, daily monitoring, weekly reporting, monthly review, conducting regular training on BBS by trained faculty, display banners for maximum awareness, empowering observee and observer, display BBS achievement at prominent locations. (i.e. Best observer, Best BBS implemented site, project BBS performance data.) and quarterly review for continual improvement are being done.

ONGC

For ONGC safety and safe behaviour has been included in the Performance Appraisal Report of individual employees. These measures helped management to sustain the BBS program even after 2 years of its launch.

Tata Projects

The simplest and most effective way to implement a BBS is to coach a set of employees on keeping an eye out for Unsafe Actions and stop by doing their bit to coach, counsel & correct their behaviours through a positive interaction. Essentially, if every one of the observers ensures they never walk past anyone working unsafely - this sets the tone for an acceptable culture that does not tolerate deviations.

AFCONS

At AFCONS BBS has been a long-drawn out approach and necessitated patience and perseverance, so, there was carefully manoeuvring for the entire process of observation and analysis. Giving-up is never a solution to the process of BBS. It needs a careful and periodic boost in the form of re-inventing the process or re-viewing for improvement.

DCM Shriram

For DCM Shriram the safety performance is continued to be assessed by tracking both leading and lagging indicators and accordingly identifying areas for building a strong safety culture at this work place. With this approach of reinforcing positive behaviour through the BBS program, it was anticipated that a *Zero Accident* goal should be achieved in the near future making safety a way of life.

Uflex Chemicals

At Uflex Chemicals though it is initial stages of BBS implementation significant improvements have been observed in the last two years. See figure 2. The company is in the process of eliminating the unsafe behaviour by 100% and promoting proactive reporting as much as possible for making this workplace site one of the safest.

Conclusion and Implications

Constant disregard for dignity to life and having a safe environment by the industry leadership led to incidents resulting in a loss of life as well as company business. *Achieving and sustaining an injury-free workplace demanded strong leadership (*Jim Spigener, 2019). BBS concept and approach, as implemented by many organizations, has resulted in positive outcomes in safety culture management. BBS has been successfully implemented in India by organisations that include Bilag, GAIL, HPCL, IOCL, L&T, AFCONS, Vedanta, Tata Projects, Sterlite, Privi, HCC, DCM Shriram, Dorf Ketal, Sembcorp, Galaxy Surfactants, SAIL, Jindal, Uflex, TRL, IGL, Agrocel, Torrent, Aarti, Solaris, CFCL, Bayer's Crop Science, Oil India, Greentech, Sanofi-Aventis, Sabic, Piramal, Bajaj Auto, Volkswagen, etc. As a result of the ISO 45001: *Occupational Health and Safety (2020),* organizations are increasingly implementing behavioural safety approach at sites. It is much easier to increase the safety time out by employees and workmen following BBS concepts (Forum of Behavioural Safety, 2020).

The safety time arithmetic of an organization depends upon the following calculation of the lead indicators numbers 1 to 8 and 10 as follows and the number 9 lag indicator.

1. Number/sufficiency/quality of BBS trainings conducted by expert.
2. Number/percentage of observers developed amongst employees for each work area.
3. Number /percentage of HODs involved.
4. Number/percentage of contractors staff involved in observation and spot-correction.
5. Number of Mass-communications held in each month.
6. Number of TBTs (Tool Box Talk) being conducted each month.
7. Number /percentage of seniors involved in observation and spot-corrections.

8. Number of monthly BBS review meetings held by departments.
9. Number/percentage of incidents reduced.
10 Whether the last person at the workplace received training in BBS and participated in observation and spot-correction of at-risk behaviours at site.

Mark each of the above aspects out of 10. Then calculate your organizational safety time score? Total score 10 x 10 = 100. This basic, practical and rapid method of calculation would decide which aspects need more focus to improve safety time score of the site. If this score is increasingly higher each month, positive outcomes of safety culture can be reaped. This overall safety time arithmetic, in turn, would affect the frequency of incidents at work sites. Some organizations are slow, whereas others are fast in obtaining this score depending upon the focus, emphasis and regular monitoring of leaders at all levels: top to bottom. Applied behavioural science is a science of actions of which BBS is an application and a planned intervention of the company management to save both life and business from incidents. People in organizations value safety when everyone engages in safety for a couple of minutes, and then it becomes an organizational value. The above 10 lead and lag indicators are mechanisms to actionize safety time.

Since the role of top managements is significant, it is important to design a BBS sensitization-training workshop for them including the components such as hazard identification, risk assessment, risk management, safety and risk control evaluation, effective communication, clarity on scientific concepts of BBS, what is BBS and what it is not. How to measure behavioural safety in organizations. Which behaviours to observe and how to interact during risk-based conversation. BBS as a well-planned and informed organizational intervention. Display of BBS banners and monthly scoreboard. How to conduct BBS steering team meeting every month, including BBS in weekly mass-communications and daily, digitally enabled BBS checklist. Understanding risk management and behavioural analysis of their own site for spot-correction. Case analysis of other organizations. How to continue and sustain this intervention. How to develop an interdependent safety culture. Monitoring of BBS outcomes and risk control measures implemented. Reward and recognition for motivation to observers. Roadmap for further implementation of BBS. Impact of at-risk behaviours on business of the company etc. This training module needs to be given to MD, CEO, all VPs, GMs, HODs including business, finance, operations etc. This approach was used in all organizations mentioned above (Kaila, 2019).

As seen at Uflex Chemicals, and at other companies, behaviour-based safety can contribute to making safety a way for life for everyone at the workplace. A motto of behaviour-based safety is to s*ave others, save yourself as big brother of safety*.

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Physical ergonomic issues in the mining industry: A review of national and international statistics

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Abstract

The mining industry can be an unsafe environment with high levels of injury due to the physical nature of manual work on mine sites. This paper examines a variety of physical ergonomic issues that are prevalent in the mining industry and contribute to the high level of work-related musculoskeletal disorders among mining workers. The most significant physical ergonomic issues within the industry are awkward postures, forceful exertion, whole-body vibration and repetitive movements. Throughout this review, the physical ergonomic issues have been analysed and the effects discussed, looking at different mining environments both nationally and internationally. This paper examines the types of work-related musculoskeletal disorders result from mining work and how the physical ergonomic issues can be prevented.

Introduction

The mining industry is classified as being relatively unsafe in comparison to other industries, with workers in the field being more vulnerable to suffering fatal and non-fatal injuries and illnesses due to the physical nature of manual work (Kim, 2018). Australian figures show four fatalities occurred in the 2017-18 period as well as 296 serious lost time injuries which lead to workers having two or more weeks off work. Injuries to the back, knee, shoulder and hand made up the largest proportion of the serious injuries and occurred mostly in the form of sprain, strain or fracture. The type of accidents that contribute to the high injury rate on mine sites are usually caused by over-exertion, strenuous movements and stepping all of which are physical (Department of Mines, Industry Regulation and Safety, 2019).

Mining workers are exposed to a variety of physical ergonomic issues which include awkward postures, forceful exertions, vibrations and repetitive movements which elevate the risk of work-related musculoskeletal disorders developing (Tak et al., 2011). Because mining workers are in a dynamic and challenging environment, they are exposed to heavy physical work, long displacements, sedentary work in awkward positions and little variation in tasks, which increases the number of risk encounters and poses risks to the health and safety of workers. The mining industry is focused on economic profit, quality and productivity, so the issues of physical ergonomics can often be rejected. Implementing more effective physical ergonomic principles can help to improve this unsafe environment (Arruda & Gontijo, 2012).

Methodology

systematic review of articles was performed initially using the Curtin University Library with the keywords ‘physical ergonomics’ and ‘mining’ used and further filtered to peer-reviewed, full-text and English only articles between the years of 2010-2020. This refined the search down to 1,389 results with three of the articles being taken into consideration for use in the literature review. Additional resources were found using Google Scholar, ProQuest, ResearchGate and by back-searching through bibliographies in resources using the same search criteria and keywords. A total of 43 articles were obtained from the above sources, abstracts were examined, and irrelevant articles were excluded (-22).

A total of 21 publications are cited in this literature review, several being qualitative research discussing the emerging physical ergonomic issues in the mining environment. Eight of the publications are research studies, four are journal articles, three are books and six are government resources. Searches were also conducted on the Australian Government and Safe Work Australia website where six further resources were accessed.

Discussion

There are several issues with physical ergonomics in mining environments including awkward postures, forceful exertion, vibration in the body and repetitive movements. These issues all lead to work-related musculoskeletal disorders and other injuries if suitable control measures are not put into place. A variety of national and international statistics examine the effect of physical ergonomic issues on mining workers (Lööw, Johansson, Andersson & Johansson, 2018).

Awkward Postures

Awkward postures refer to manual tasks on mine sites that include scenarios such as lifting objects above and below the normal bodily range, working with the back, neck or wrist bent without support or squatting/kneeling for long periods. Such postures cause discomfort as they significantly deviate from the neutral position of joints (Horberry, Burgess-Limerick & Steiner, 2011). In a study researching the prevalence of ergonomic risks factors in underground mine sites in Zambia, 202 male mine workers were questioned. 100 out of the 202 mine workers reported having to work in awkward postures as part of their daily jobs, with electricians and mechanics on the mine site suffering the most. 87% of the electricians on the mine site and 66% of the mechanics reported working in awkward postures for long durations which included bending and twisting the neck and back, working above their heads and excessive kneeling which contributes to the overall large prevalence of lower back and wrist/hand injuries in the Zambian mining sector (Kunda, Frantz & Karachi, 2013).

To avoid mining workers working in awkward postures, manual tasks should be limited to movements that are within the neutral joint range. This is a challenge especially in underground mine sites where there is restricted space available and it is a necessity to work in awkward postures. At the very least, grasp reach limits should be within the range of the smallest limiting user and all controls be able to operate without workers having to stay in awkward postures for long periods (Horberry et al., 2011).

Forceful Exertion

Handling heavy loads in the form of pushing, pulling, holding, lifting and lowering causes injury in the body from the force being greater than certain body parts can resist. Forceful exertion includes short-term exposure to a relatively large force (sudden-onset injuries) or accumulation of muscle damage from long-term exposure beyond the tissue's capacity (gradual-onset injuries). The likelihood of injury depends on the level of force involved, the distance of the load from the body, the mass of the load and the friction involved. High-speed movements and rapid changes in direction of movement reduce the strength of muscles and increase the risk of injury (Horberry et al., 2011).

In mine sites, most injuries are caused by the small forces required in simple tasks that create small tears in the muscles and lead to long-term injury over time. Roof bolting is a primary task on mine sites that can be physically demanding and requires continuous forceful exertions in awkward postures and confined environments. The mine safety and health administration (MSHA) study examining roof bolting data from 2003-14 in the U.S. showed that roof bolting caused 3,411 lost-time injuries resulting in 213,254 lost working days. From this data, it is evident that tasks such as roof bolting on mine sites can create strain in the body affecting the shoulders, back, forearms and neck and needs intervention to reduce the risk of long-term injury (Sammarco, Podlesny, Rubinstein & Demich, 2016).

Whole Body Vibration
Whole-body vibration (WBV) is a common physical ergonomic issue in mining environments. WBV most commonly occurs when driving heavy earth moving machinery (HEMM) such as dozers and trucks. In a study of the effect of HEMM on workers' health in Indian mines, the conducted surveys show that vibration levels when operating the machinery were greater than the ISO recommended standards, increasing the risk of adverse health effects occurring in workers (Mandal, Sarkar & Chatterjee, 2011). Another study conducted by Mandal et al. (2011) concluded that out of 117 HEMM operators, 100% of dozers, 95% of loaders and 90% of dumpers and tippers experienced frequent whole-body vibrations leading to detrimental health risks. Out of a further 48 HEMM operators, 85% complained of WMSDs in the back, shoulder, knees and neck.

Exposure to WBV disturbs working comfort, working efficiency and compromises workers' health and safety which is a contributing factor for musculoskeletal disorders mostly affecting the spine and lower back. Vibration is usually transmitted through the floor or seat in heavy vehicles and machinery when driving over rough surfaces (Safe Work Australia, 2018). According to the International Organisation for Standardization (ISO) who released the ISO 2631-1:1997 standard, a worker can be exposed to a total of $8.5m/s^{1.75}$ vibration dose value (VDV) in 8 hours, but if a worker works a longer shift and has a 12-hour exposure, the intensity must be lowered to account for the additional exposure. If the exposure goes higher than $17m/s^{1.75}$ (VDV) this is likely to cause a risk to the workers' health. The standard states that the effects of WBV may be manifold, including causing discomfort, physiological damage and influencing performance capability, alongside several other health and safety issues (ISO, 1997).

Repetitive Movements
Task repetition includes inadequate variation and excessive periods of tasks that are either physically or mentally demanding (Department of Mines, Industry Regulation and Safety, 2014). In the mining environment, repetitive work comes in the form of manually tightening bolts, using equipment controls such as joysticks and grease guns. This increases the pressure on nerves and creates damage over time (NIOSH, 2018). In a U.S. study completed in 2010, researching the national burden of physical ergonomic hazards among workers, repetitive motion was the most prevalent issue affecting 27% of U.S. workers daily. Of the 4,950 miners surveyed, 97.1% reported making repetitive motions for more than half of the time in their job (Tak & Calvert, 2011).

Repetition is extremely common in mining environments as workers are commonly operating large machinery, this can lead to extended periods of bending the neck and back to view work properly and twisting of the body while reversing (Safe Work Australia, 2018). Repetition is not just common when operating heavy earth moving machinery, another common issue in mining environments is the lifting of heavy objects repetitively in the processing plants. This contributes to the high level of wrist sprains and other musculoskeletal disorders among mining workers (Department of Mines, Industry Regulation and Safety, 2019). Other areas of the body include the legs and arms that are constantly being elevated and put into non-neutral positions while bending down and reaching up in processing plants (Tak et al., 2011). Repetitive movements are an ergonomic issue as they slowly break down certain muscles of the body and lead to long-term injury.

Work-related Musculoskeletal Disorders
Work-related musculoskeletal disorders (WMSDs) are chronic disorders that cause damage to the tendons, muscles, nerves and vascular system of humans and are a result of a persons' work activities. Over the last couple of decades, the mining industry has shifted its focus away from manual labour and towards a mechanised way of working. Many mining jobs are spent operating heavy earth moving machinery including loaders,

excavators and dumpers. But many mining jobs still include strenuous work that includes mining workers doing their work in awkward postures, with repetitive forceful exertions and vibrations that contribute to musculoskeletal stress. Neglecting ergonomic principles in the mining industry leads to the high prevalence of WMSDs including joint pains, backache and cervical spondylitis. Those who work underground are at a higher risk of developing a WMSD, especially in the neck and low back regions as they are in confined environments (Mandal, 2014).

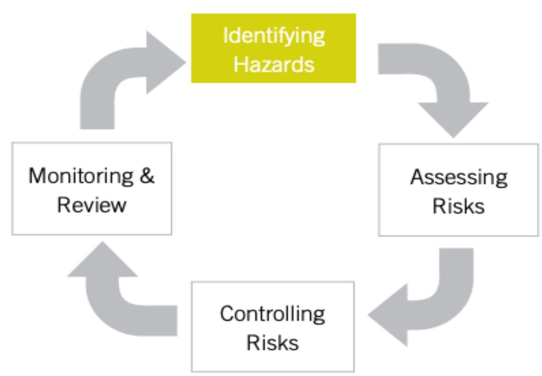
In a study conducted by Mandal & Manwar (2017) forty-six operators from an opencast mine in India were recruited for a cross-sectional study on the prevalence of musculoskeletal disorders among heavy earth moving machinery operators. The results of the study showed that lower back pain was the most prevalent WMSD and overall the risk analysis showed an increase in the likelihood of developing a WMSD because of the high exposure to risk factors such as WBV. Overall, 83% of the subjects reported having lower back pain, 30% of the group reported having neck pain, 30% knee pain, 28% shoulder pain and 39% of the group required some sort of medical attention over the course of their work at the mine site. WMSDs are also reported to be highly prevalent among miners in Australia, USA, Sweden and Spain, with other countries having a lack of awareness and statistical evidence of the issue (Elgstrand & Vingard, 2013). The prevention of WMSDs is one of the most current risk control needs of the mining industry, with the physical activity levels of mining workers reaching unhealthy limits in many countries (Elgstrand & Vingard, 2013).

Controlling Physical Ergonomic Issues

To control physical ergonomic issues in the mining industry, a series of preventative control measures need to be put into place on mine sites. Firstly, a strong top-down commitment to management is essential. A risk management approach is effective to promote a participative ergonomics approach to health and safety. (Department of Mines and Petroleum, 2010).

The physical ergonomic issues that have been discussed in this review should be identified in all mine sites with the risks assessed. To control the hazards, the hierarchy of risk control measures should be implemented and where practicable, exposure should be limited to the risk factors of awkward postures, forceful exertion, whole-body vibration and repetitive movements and where possible these risks should be eliminated (Department of Mines and Petroleum, 2010). Workers must be selected based on their physical capabilities to maximise the fit between the work environment and the person and the limiting users of equipment should be taken into account. The cost of implementing long-term ergonomic strategies would ultimately be regarded as an investment with benefits to the health and safety of all mining workers (Schutte, 2011).

Figure 1
Risk Management Process



Note. From *National Code of Practice for the Prevention of Musculoskeletal Disorders from Performing Manual Tasks at Work* (p. 23), by Safe Work Australia, 2007, Commonwealth of Australia (https://www.safeworkaustralia.gov.au/system/files/documents/1702/nationalcodeofpractice_preventionofmusculoskeletaldisordersfromperformingmanualtasksatwork_2007_pdf.pdf). Copyright 2007 Commonwealth of Australia

Automation and mechanisation of mining equipment is an emerging risk control measure that reduces WMSD levels at mine sites, increasing productivity and reducing physical activity levels in workers. Manual handling should be avoided where possible and tasks should be redesigned to replace high risk activities with low risk activities (Dempsey, Kocher, Nasarwanji, Pollard & Whitson, 2018). The design of machinery and equipment should be the biggest focus and operators should be trained and further upskilled to promote healthy working conditions. Vibration levels in HEMM should be regularly monitored, road conditions examined, speed limits should be set and regular breaks 'out of seat' should be implemented. Any control measures put into place should be monitored and reviewed regularly and new strategies put into place if needed (Lööw et al., 2018).

Conclusions

Overall, the mining industry is a high-risk environment where physical ergonomic issues are prevalent. Work-related musculoskeletal disorders are a serious and emerging issue on mine sites, especially for underground mine workers and those who operate HEMM. Appropriate risk control measures need to be put in place to protect the health and safety of mining workers around the world and create a healthy mining environment.

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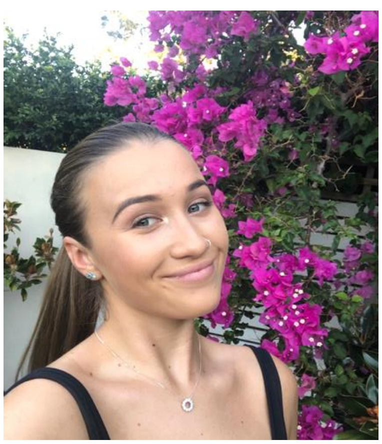

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New Employees Accident and Injury Rates in Australia: A review of the literature

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Abstract

According to the Australian Bureau of Statistics (ABS, 2018) every year in Australia there are more than half a million work related accidents and injuries. The financial, human and social costs of work related accidents and injuries are a major concern for not only individual workplaces but at all levels for International and National authorities. International research since 1917 has consistently demonstrated that, irrespective of age, experience and industry, the occupational group at greatest risk of accidents and injuries are those employees with less than 12 months experience in their current job role. Whilst the elevated risk for new employees has always been concerning, recent organisational developments such as globalisation and increased non-standard employment, as well as workers changing jobs more frequently have strengthened these concerns. A review of the Australian and International literature has shown that approximately 30% to 40% of new employees sustain an injury within the first year of employment. Research in Australia on this topic, however, appears to be lagging and is worthy of further attention and a stronger focus on how to remediate this global issue. Compared to other countries such as Canada, Italy, France, Thailand, Africa and America, Australia has limited research on new employee accident and incident rates available, reflecting a lack of focus on this issue. The Australian data shows that in general, the workforce is evolving and that the incident rates change depending on new employee rates.

Keywords: New Employees. Accident Rates. Injury Rates. Tenure. Age. Turnover. Safety.

Introduction

Accident and injury rates in Australia are still unacceptably high and the financial, human and social costs are a major concern. In 2016, there were 182 work related fatalities in Australia, in comparison to other countries such as United States (5,190) (Bureau of Labour Statistics 2016), Canada (905) (Association of Workers Compensation Boards of Canada 2016) and United Kingdom (137) (Health and Safety Executive 2016). In 2018 in Australia, 563,600 or 4.2 percent of the working population experienced a work-related injury (ABS, 2018). According to Safe Work Australia (SWA, 2015), work related injuries (WRI) cost the Australian economy over $61.8 billion in the 2013-2014 financial year [4.1% of Gross Domestic Product (GDP)]. These costs had increased by $1.2 billion dollars since the 2008-2009 financial year.

Whilst the elevated risk of injury for new employees, defined here as *employees with less than 12 months experience in their current job role*, has always been alarming and globalization, increased non-standard employment as well as workers changing jobs more frequently, have strengthened these concerns (Arthur & Rousseau, 1996; Hall, 1996; McCrindle, 2014). According to Breslin and Smith (2006), the one group at greatest risk of accidents and injuries are new employees, irrespective of age or industry. This is supported by many years of International research that has continually demonstrated that new employees are at a higher risk of accident and injuries than workers with extended tenures (Breslin & Smith, 2006; Burt, 2015; Cellier, Eyrolle & Bertrand, 1995; Cook, 2003; Hertzman, McGrail & Hirtle, 1999; Molleman & van der Vegt, 2007; Root & Hoefer, 1979; Siskind, 1982).

Very early research into this area conducted by Chaney and Hanna (1917) in the iron and steel industry in America, found that workers with less than six months of tenure had injury rates thirteen times higher than workers with ten years of tenure. More recently, Breslin and Smith (2006) found that workers within one month of employment had twice the lost time injuries claims, and were four times more likely to sustain injuries, than workers with over twelve months experience in their current job.

The Centre for Economic and Business Research in conjunction with the Hay Group (2012) stated that the number of workers changing their employment would reach 161.7 million worldwide in 2014, indicating a growing issue with employee turnover rates, particularly related to an aging population. They also claimed that economic expansion will lead to disgruntled employees taking opportunities to change jobs. The projected global turnover clearly indicates that not only could millions of employees be leaving their jobs, but that millions of people will also become new employees (Hay Group, 2012). The Asia-Pacific region was one area that was identified as being likely to see the greatest increase in turnover (21.5% in 2013 to 25.6% in 2018). The number of people expected to change jobs due to loss of jobs through COVID-19 business closures, and the reopening of businesses in the aftermath may also see a huge increase in people entering jobs for which they have little or no previous experience. At this point in time both dormant organisations and out of work people will put pressure on governments for a large scale 'back to work' to minimise economic damage and with many also seeking relief from social isolation (Business Continuity Institute, 2020). With these changes to the workforce and it is important for the situation in Australia to be investigated and understood.

Methodology

An extensive literature review was conducted using a wide range of academic search engines that included, ResearchGate, Discover It, Trove, PsychINFO, ERIC and Academia databases to retrieve articles from keywords, title and abstracts. A mixture of Boolean operator and search terms 'new employees, 'novice employees' and 'accident and injury rates' were used for these searches. Full-text articles were then subsequently reviewed after a primary screening of abstracts against relevance to the research topic. These were then further limited to articles that included fatal and non-fatal injuries in the workplace. A world-wide-web search for grey literature using the above terms was also conducted using the Google Scholar internet search engine. A total of 82 publications are cited in this article. Publications reviewed include 56 journal articles, 23 web publications and 3 books.

What is a New Employee?

Defining a new (novice) employee is complex. According to the Oxford Learners Dictionary (2020, p.1), a novice is "a person who is new and has little experience in a skill, job or situation". New employees have been defined variously in the international literature, ranging from workers who have never had a job to those with 18 months' work experience to some studies stating up to 8 years of work experience (Dababneh, Lowe, Krieg, Kong, & Waters, 2006; Dahlgren, Hult, Dahlgren, Hard af Segerstad, & Johansson, 2006; Smith & Comyn, 2003). Another measure is age (Breslin & Smith, 2006). The typical new employee is young, and has recently entered the workforce, however this concept can be challenged as mature workers that change occupations or jobs are also be considered as new employees. Therefore, age is an incomplete proxy measure for a new employee, especially taking into consideration the current and predicted changes in the workforce. Another common approach that fails to capture the complexity of defining a new employee is experience (Schoemaker, Barreto, Swerdlow, Higgins, & Carpenter, 2000). Experience has been described as a linear journey from new to expert based on the assumption that with the passing of time, skills and proficiency increase. According to

Molleman and van der Vegt (2007), new employees are defined not only as any person that has recently commenced work but can also apply to any person that has previously worked in other employment that is new to the workplace.

The common denominator for new employees according to Ehsani and Ibrahim (2008) is the novitiate period and not age, level of experience or stage achieved in their career. The novitiate period is the length of time where the new employee adjusts and masters a new task, role or environment (Ehsani & Ibrahim, 2008). For the purpose of this review, a new employee will be defined as ‘a worker that has recently started work with their current employer, irrespective of age and experience, and is within the first 12 months in any industry’.

International View

New employee accident and injury rates have been addressed by three key bodies of research which all clearly indicate that new employees are more likely to sustain an injury in the workplace within the first year. The larger two bodies of research studied the correlation between tenure and accidents as well as age and accidents (Groves, Kecojevic & Komljenovic, 2007; Laflamme, 1996; Leigh, 1986; Root & Hoefer, 1979; Salminen, 2004). Age research focused mainly on youth populations, which may or may not always be classed new employees. Unfortunately, the research conducted between age and accident/injury rates did not separated the correlation between age and tenure. Finally, a smaller body of research explored the relationship between employee turnover and accident rates. It was suggested that one relevant aspect that is related to both employee turnover and accident rates is dissatisfaction with safety, in particular, safety risk perceptions, that escalates turnover intentions (Cree & Kelloway, 1997) and showed that dissatisfaction was not related to the length of tenure. Satisfaction with the work environment has also been linked to fewer cognitive failures which can lead to accidents and higher human performance related safe work behaviour (Klockner, 2018).

Variable 1 - Tenure and Injury Rates

The Bureau of Labor Statistics in the United States of America published a study conducted by Chaney and Hanna (1918) that showed accident rates in relation to the length of service (tenure) between 1907 and 1917 in the iron and steel industry. This is the earliest available report that analyses accident rates of both new employees and workers with ten to fifteen years of tenure (Chaney & Hanna, 1918). Results showed the accident frequency rate of 111.3 per 1,000 for 300-day workers for workers within a 6-month tenure period compared to 8.5 per 1,000 300-day workers for over 10 years of tenure (Chaney & Hanna, 1918). The authors did not define what a 300-day worker is (Chaney and Hanna 1918). A century later, research still persistently demonstrates that new employees are more likely to be injured than those that have been employed over twelve months (Breslin & Smith, 2006; Siskind, 1982). These studies were only based on tenure and did not distinguish between age groups.

In 1979, Root and Hoefer (1979) conducted a comparative study in 10 American States using worker’s compensation data between 1976 and 1977. They analyzed the reports of over 270,000 work injuries from the ten states and found that 40% occurred within the first twelve months of employment and that over half were in the first three months (Root & Hoefer, 1979). The findings have been supported in a more recent study conducted by Bena, Leombruni, Giraudo and Cost (2012) who analysed the Italian National Social Security Institute (INPS) and the National Insurance Institute for Occupational Injuries (INAIL) databases between 1994 and 2003. Bena et al. (2012, p. 529) report “[w]orkers with a short job tenure have a 40% higher probability of suffering an injury compared to workers with more than 3 years of tenure.”

A comprehensive study conducted by Leigh

(1986) attempted to establish the contribution of personal factors, such as education, age, and experience, and job-related factors, such as overtime, tenure and hazardous conditions as well as, accident and injury rates. Logistic regression was used to analyse these relationships from a sample of 4,962 participants taken from the 'University of Michigan's Panel Study of Income Dynamics for 1978 and 1979' (Leigh, 1986) and a key finding was that participants with a shorter tenure, or new employees, reported more injuries and demonstrated a higher accident rate.

In more recent studies the association between tenure and accidents has been investigated within the mining industry. Groves et al. (2007) conducted a study of equipment-related injuries between 1995 and 2004 using data from the Mine Safety and Health Administration (MHSA) and the Current Population Survey (CPS) in America. Twenty-eight percent of the 86,398 injuries and 31% of the 597 fatalities investigated occurred in the first year of tenure (Groves et al., 2007).

Research undertaken in other industries has found similar trends between tenure and accident rates. Bentley, Parker, Ashby, Moore and Tappin (2002), used simple frequency distribution, cross tabulation and content analysis of the New Zealand Accident Reporting Scheme (ARS) database between 1995 and 1999 in their investigation of the timber logging skid sites of New Zealand. They found that 44% of the 242 lost time injuries occurred within the first year of tenure and that 32% occurred with the first six months of tenure.

In the transport industry, McCall and Horwitz (2005) reviewed 1,168 claims from worker's compensation data in Oregon between 1990 – 1997 using benchmark statistics from the US Bureau of Census Current Population Surveys and stated that 51% were by drivers with less than a year in their current role. Overall the research discussed points towards a strong linkage between tenure and accidents and suggests that as tenure increases accidents decrease. However, it is not the only variable that needs to be considered.

Variable 2 - Age and Injury Rates

There has been debate about the connection between age and accident and injury rates in the literature. Some studies have found no differences among various age groups, (Butani, 1988; Kisner & Fosbroke, 1994; Webb, Redman & Sanson-Fisher, 1992) yet other studies have found a higher rate of injuries among younger and older age groups than middle age groups (Alsop, Gafford, Langley, Beg, & Firth, 2000). Safe Work Australia (2020a) report that young workers, aged under 25 years, fatality rates increased to 13% in 2018, up from 8% in 2017 and was the only age group that did have an increase in fatalities. However, in relation to serious injury workers' compensation claims, older workers accounted for 25% of claims and are more likely to make a claim than workers under 25 years who account for only 15% of these types of claims (Safe Work Australia, 2020b). In fact, the 15-19 year old workers had the largest drop (47%) in numbers of serious injury claims for any age group over a 6 year comparison period whereas older workers' age groups had major increases i.e. 55-59 age group (46%), 60-64 age group (114%) and 65+ age group (306%) (Safe Work Australia, 2018b).

Others state that accident rates decline with age (Breslin & Smith, 2005; Laflamme & Menckel, 1995; Salminen, 2004). As well as the contradictory findings there are various explanations proposed. For example Laflamme and Menckel (1995), Layne Landen (1997) and Root (1981) propose that older workers have lower accident and injury rates because they are more experienced and more aware of safety hazards while Kenny, Groeller, McGinn and Flouris (2015) and Pransky, Benjamin, Savageau, Currivan and Fletcher (2005) suggest that older workers have higher accident rates because of declining cognitive function and overall physical and recuperative abilities.

Other studies have stated that younger workers have higher accident rates due to recklessness, inexperience and are allocated the more dangerous tasks (Prenesti, 1996; Wortham, 1998). In contrast it has been suggested that younger workers have lower fatality rates due to superior reflexes and less exposure to more dangerous jobs that require more experience (Chen & Fosbroke, 1998; Driscoll, Mitchell, Mandryk, Healey, Hendrie, & Hull, 2001; Peek-Asa, Erickson & Kraus, 1999).

Literature about young workers is confusing as researchers attribute high injury rates to different contributing factors. For example, it has been suggested that inexperience and underdeveloped cognitive abilities characterised by a perception of vulnerability among younger workers are factors (Prenesti, 1996; Wortham, 1998). However, this has been challenged by Breslin, Pole, Tompa, Amick III, Smith and Johnson (2007) after conducting a systematic literature review and finding that occupation and workplace influences, such as overload and physical hazards, significantly affected the likelihood of work-related accidents and injuries. A list of factors from this review included, training, supervision, cognitive and physical development as well as the social environment of the workplace (Breslin et al., 2007). There was no one single factor that explained higher injury rates to younger workers. There is, however, a substantial amount of literature on young workers' risk perception (Lapsley, Aalsma, & Halpern-Felsher, 2005; Reyna & Farley, 2006; Mbaye & Kouabenan, 2013). Perceived seriousness, probability and vulnerability also appear to have a significant influence on protection motivation (Weinstein & Nicolich, 1993).

In population-based research exploring differences in age-related work injuries, elevated risks were found among 15 – 24 year-olds (Laflamme & Menckel, 1995; Salminen, 2004). A methodological concern is that factors used to estimate rates are established using a number of workers in each age group and not hours worked. Young workers are more likely to work part-time and by calculating rates based on a number of workers, it potentially underestimates the risk of injury (Castillo, Landen & Layne, 1994; Ruser, 1998). Confounding the analysis of age differences in accident and injury rates is that most young adults and adolescents do different work to older adults (Chau, Gauchard, Dehaene, Benamghar, Touron, Perrin & Mur, 2007), and may be exposures to different hazards.

The complication with differentiating the age and job tenure association in the literature is possibly due to the broad range of ages that can be frequently applied to different research studies to differentiate the young worker or group. Categorising 'young workers' on the basis of age is a very common practice in this area of research (Breslin et al., 2007; Chau et al., 2007, Rasmussen, Hansen, Nielsen & Anderson, 2011) along with undertaking safety prevention campaigns directed at young workers (Safe Work Australia 2017b). Young workers are usually thought of as a single group with similar outlook and circumstances in the labour market. One explanation is that age is a straightforward classification that can occasionally contribute to a proxy group for 'young worker', yet, it also risks exaggerating the significance of biological age in accident and risk analysis.

Turnover and Injury Rates

Given the large amount of research that indicates tenure and accident rates are linked, it might be expected that there would be a significant amount of work around the correlation between employee turnover and accident rates. Employee dissatisfaction is fundamental common reason for employees not remaining in their present job (Griffeth, Hom & Gaertner, 2000; Holtom, Mitchell, Lee & Eberly, 2008; Hom &Kinicki 2001) and one factor contributes to this is safety risk perception (Cree & Kelloway 1997). Therefore, while turnover leads to the introduction of new employees' dissatisfaction with safety can also cause employees to leave their jobs. However, research exploring this is limited.

New employees take considerable time to reach full efficiency and are more likely to be error-prone than their experienced counterparts (Atkinsons and Hargreaves. 2014). Atkinson and Hargraves (2014) found that high turnover can increase the risk of safety incidents. They also found that new employees with consequent communication lapses can create more opportunities for errors. It is more challenging to build a positive safety culture if the composition of the workforce is constantly changing (Atkinson & Hargraves, 2014; Beach, Brereton & Cliff, 2003). It would then also be anticipated that an increase in accident rates would be linked with the number of new employees introduced in the workforce.

A study conducted by Bell and Grushecky (2006) into timber logger safety in West Virginia found that high turnover within organisations can present problems in relation to safety and accident and injury rates. They found that organisations with high turnover also demonstrated higher accident rates compared to those organisations with lower turnover rates (Bell & Grushecky, 2006). Often the replacement worker has less familiarity or lack of specific knowledge with the unique characteristics of the workplace. This includes familiarity in the context of environment, materials and how the job is done (Goodman & Garber, 1998). At present, it is unclear whether increased employee turnover is positively correlated with increased accident and injury rates for new employees so further research is required.

The Australian Context

The literature around new employees and injury rates in the Australian context is limited. What is available does, however, support many of the international findings. In some Australian industries, high turnover rates can be attributed to a skills shortage giving workers improved opportunities to seek higher wages elsewhere (Australian Mines and Metals Association [AMMA] 2013). The Australian Bureau of Statistics (2012) found that, 13% of workers had changed their jobs in 2011, an increase of 9% since 2010. A report released by Australian Human Resource Institute (2015) states that the average rate of turnover in Australia was 16% across all industries and Farren (2007) found that 22% of new employees left their job within the first 45 days. This indicates that employees are more open to seeking new opportunities and decreases the length of time they expect to stay with an organisation.

Many Australian industries are experiencing a constantly changing workforce that can be consistent in total number of employees, yet variable with regards to the composition of that workforce. Alternatively, some workforces can continually grow as demands increase, resulting in a continuation of new employees in the working environment. Furthermore, in response to the challenges of globalisation, organisational reforms over the past thirty years have driven changes in working arrangements and relationships that in turn have created new health and safety hazards and risks (Zwetsloot, 2003).

Organisational structures in the Australian workforce over the past few decades have seen a percentage increase of new employees in the workforce. Growth in non-standard employment has also bolstered the proportion of new employees in the labour market. For example, from 1985 to 2005, part-time workers aged 15 – 64 increased from 20% to 27% of the labour market (ABS, 2007); from 1973 to 2003 young workers aged 15 -24 working part-time doubled from 18% to 47% (ABS, 2004). The rise of part-time employment labour markets is increasingly casual in nature. Casual employment doubled from 1982 to 2002 and is steadily increasing. In 2006, 40% of young workers were in casual employment despite constituting 21% of the total workforce (ABS, 2001; ABS, 2006).

Another compounding aspect that contributes to the large pool of newly hired workers is the social and cultural phenomenon of people changing jobs more frequently than was previously the norm (Papadopoulos, Georgiadou, Padazoglou & Michaliou, 2010). According to McCrindle Research (2014), it is estimated that a person from the age of 18 to retirement will have in excess of seventeen new jobs in their working life in Australia. As widespread organisational downsizing and restructuring are now typical in today's global economy (Littler, Wiesner, & Dunford, 2003), it is now widely accepted that life-long employment security is not a practical goal as more and more Australians are ready to become more mobile (Arthur & Rousseau 1996).

Australian Research

Despite all of the disturbing findings regarding higher accident and injury rates among new employees, perception and recognition of the scale of the problem remains notably under-researched in Australia. Analysis of work-related injury data enables identification of hazards and targets for prevention as well as the benchmarking of national health and safety performance. Over the past few decades, periodic collection of work-related fatal injury data has been reported within Australia (Harrison, Frommer, Ruck & Blyth 1989; National Occupational Health and Safety Commission, 2004). These research papers have concentrated on the internal correlation of distribution and nature of injury occurrence for all workers and not on international comparisons (Ore & Stout 1996; Stout, Frommer & Harrison, 1990). They have also not assessed length of tenure in relation to accident rates. To identify research priorities and assess Australia's performance, international comparisons can add value to the understanding with relation to accident/injury rates of new employees.

Conclusion

A review of the International research indicates that new employees sustain more accidents and injuries within the first twelve months of employment. Although there is variation in the research methodologies and causation around theoretically confounding issues, the evidence indicates that the group at highest risk of accidents and injuries is new workers.

There appears to be little research in Australia recognising the risks that face both employers and their new employees in their first twelve months on the job. What is reported is that in Australia there will be numerous reasons why the number of new employees in the workforce will increase. Australian workplaces may need to have a stronger focus on how to manage new employees' safety risks in order to reduce the accident and injury rate trending for this population, otherwise, Australia may experience a rise in accidents and injuries in parallel to the arrival of new employees to the workforce.

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World Safety Organization (WSO)

The WSO was founded in 1975 in Manila, The Republic of the Philippines, as a result of a gathering of over 1,000 representatives of safety professionals from all continents at the First World Safety and Accident Prevention Congress. The WSO World Management Center was established in the United States of America in 1985 to be responsible for all WSO activities, the liaison with the United Nations, the co-operation with numerous Safety Councils, professional safety/environmental (and allied areas) organizations, WSO International Chapters/Offices, Member Corporations, companies, groups, societies, etc. The WSO is a not-for-profit corporation, non-sectarian, non-political movement to ***"Make Safety a Way of Life… Worldwide."***

World Safety Organization Activities

WSO publishes WSO Newsletters, World Safety Journal, and WSO Conference Proceedings.

WSO provides a network program linking various areas of professional expertise needed in today's international community.

WSO develops and accredits educational programs essential to national and international safety and establishes centers to support these programs.

WSO receives proposals from professional safety groups/societies for review and, if applicable, submits them to the United Nations for adoption.

WSO presents annual awards: The James K. Williams Award, Glenn E. Hudson International Award, J. Peter Cunliffe Transportation Award, Concerned Citizen, Concerned Professional, Concerned Company/Corporation, Concerned Organization, Educational Award, WSO Chapter/National Office of the Year, and Award for Achievement in Scientific Research and Development.

WSO provides recognition for safety publications, films, videos, and other training and media materials that meet the WSO required educational standards.

WSO establishes and supports divisions and committees to assist members in maintaining and updating their professional qualifications and expertise.

WSO has Chapters and National/International Offices located throughout the world, providing contact with local communities, educational institutions, and industrial entities.

The WSO organizes and provides professional support for international and national groups of experts on all continents who are available to provide expertise and immediate help in times of emergencies.

Benefits of Membership

WSO publishes the "WSO Consultants Directory" as a service to its Members and to the Professional Community. Only Certified Members may be listed.

WSO collects data on the professional skills, expertise, and experience of its Members in the WSO Expertise Bank for a reference when a request is received for professional expertise, skill, or experience.

WSO provides a network system to its Members whereby professional assistance may be requested by an individual, organization, state, or country or a personal basis. Members needing assistance may write to the WSO with a specific request, and the WSO, through its

Membership and other professional resources, will try to link the requester with a person, organization, or other resource which may be of assistance.

WSO provides all Members with a Membership Certificate for display on their office wall and with a WSO Membership Identification Card. The WSO awards a Certificate of Honorary Membership to the corporations, companies, and other entities paying the WSO Membership and/or WSO Certification fees for their employees.

Members have access to WSO Newsletters and other membership publications of the WSO on the WSO website, and may request hard copies by contacting the WSO World Management Center. Subscription fees apply to certain publications.

Members are entitled to reduced fees at seminars, conferences, and classes given by the WSO. This includes local, regional, and international programs. When Continuing Education Units (CEUs) are applicable, an appropriate certificate is issued.

Members who attend conferences, seminars, and classes receive a Certificate of Attendance from the WSO. For individuals attending courses sponsored by the WSO, a Certificate of Completion is issued upon completion of each course.

Members receive special hotel rates when attending safety programs, conferences, etc., sponsored by the WSO.

Membership

The World Safety Organization has members who are full time professionals, executives, directors, etc., working in the safety and accident prevention fields, including university professors, private consultants, expert witnesses, researchers, safety managers, directors of training, etc. They are employees of multi- national corporations, local industries, private enterprises, governments, and educational institutions. Membership in the World Safety Organization is open to all individuals and entities involved in the safety and accident prevention field, regardless of race, color, creed, ideology, religion, social status, sex, or political beliefs.

Membership Categories

Associate Membership: Individuals connected with safety and accident prevention in their work or individuals interested in the safety field, including students, interested citizens, etc.

Affiliate Membership: Safety, hazard, risk, loss, and accident prevention practitioners working as full time practitioners in the safety field. Only Affiliate Members are eligible for the WSO Certification and Registration Programs. **Institutional Membership**: Organizations, corporations, agencies, and other entities directly or indirectly involved in safety activities and other related fields. **Sustaining/Corporate Member**: Individuals, companies, corporations, organizations or other entities and selected groups, interested in the international effort to "***Make Safety A Way Of Life...Worldwide***."

The WSO Membership Application is included on the following pages and is also available on the WSO website:
https://worldsafety.org/application- for-wso-membership/
https://worldsafety.org/quick- downloads/

World Safety Organization Application for Membership

[✓] Application Fee $20.00 USD
[ ] Associate Membership $65.00 USD
[ ] Affiliate Membership $90.00 USD
[ ] Institutional Membership*) $195.00 USD
[ ] Corporate Membership*) $1000.00 USD

*) In case of institution, agency, corporation, etc., please indicate name, title, and mailing address of the authorized representative.

(Please print or type.)

NAME (Last, First, Middle) [ ] Mr. [ ] Ms. [ ] Mrs. [ ] Dr. [ ] Engr.	
BIRTHDATE:	
POSITION/TITLE:	
COMPANY NAME AND ADDRESS: [ ] Preferred	
HOME ADDRESS: [ ] Preferred	
BUSINESS PHONE:	FAX:
CELL PHONE:	HOME PHONE:
E-MAIL ADDRESS(ES):	
PROFESSIONAL MEMBERSHIP(S), DESIGNATION(S), LICENSE(S):	
EDUCATION (degree(s) held):	

REFERRAL

If you were referred by someone, please list his/her name(s), chapter, division, etc.:

WSO Member: ______

WSO Chapter: ______

WSO Division/Committee: ______

Other: ______

PLEASE specify your area of professional expertise. This information will be entered into the WSO "Bank of Professional Skills," which serves as a pool of information when a request for a consultant/information/expertise in a specific area of the profession is requested.

[ ] Occupational Safety and Health (OS&H)
[ ] Environmental Safety and Health (EH&S)
[ ] Fire Safety/Science (FS&S)
[ ] Safety/Loss Control Science (S&LC)
[ ] Public Safety/Health (PS&H)
[ ] Construction Safety (CS)
[ ] Transportation Safety (TS)
[ ] Industrial Hygiene (IH)
[ ] Product Safety (PRO)
[ ] Risk Management (RM)
[ ] Hazardous (Toxic) Materials Management (HAZ)
[ ] Nuclear Safety (NS)
[ ] Aviation Safety (AS)
[ ] Ergonomics (ERG)
[ ] Petroleum (PS)
[ ] Oil Wells (OW)
[ ] Other: ______

PAYMENT OPTIONS

For secure Credit Card Payment, please visit the SHOP on WSO's website (https://worldsafety.org/shop) and select "WSO Membership Application Fee" to make your payment. You will receive an emailed invoice for the Membership Fee upon approval.

Check or Money Order payable to WSO may be mailed with application packet to: WSO-WMC, Attn: Membership Coordinator, PO Box 518, Warrensburg MO 64093 USA. International postal money orders or bank drafts with a U.S. routing number are acceptable for applicants outside the United States. For alternate payment arrangements, please contact WSO-WMC.

Annual dues hereafter will be billed and payable on the anniversary date of your membership. **U.S. funds only.**

By submitting this application, you are accepting that WSO will use the information provided to perform an independent verification of employer, credentials, etc.

Mail or email completed form, along with current résumé/CV:

WSO World Management Center
PO Box 518 | Warrensburg, Missouri 64093 USA
Phone 660-747-3132 | FAX 660-747-2647 | membership@worldsafety.org

Student Membership Application

WORLD SAFETY ORGANIZATION

Instructions | Complete all applicable fields and mail to **WSO World Management Center, PO Box 518, Warrensburg, MO 64093 USA**, email to **membership@worldsafety.org**, or fax to **1-660-747-2647**. For assistance completing this application, please call **1-660-747-3132**, or email questions to **membership@worldsafety.org**.

Membership Level | Choose One

☐ **College/University Student Membership – FREE**

*You will receive all member benefits including subscriptions to **WSO World Safety Journal** and **WSO NewsLetter**, as well as access to **WSO's Mentor Program**.*

☐ **Middle/High School Student Membership – FREE**

*You will receive all member benefits including subscription to **WSO World Safety Journal** and **WSO NewsLetter**, excluding access to **WSO's Mentor Program**.*

Last Name/Family Name

First Name/Given Name | Initial | ☐ M ☐ F (Gender)

Birthdate MM / DD / YYYY (Application must include exact birthdate with year to be processed.)

Current Street Address ☐ On Campus ☐ Off Campus (Attach separate sheet if you need more room for your address.)

City | State/Province | Country

Zip/Postal Code | Telephone Number (including area code) | ☐ Landline ☐ Mobile (Type)

Permanent Street Address

City | State/Province | Country

Zip/Postal Code | Telephone Number (including area code) | ☐ Landline ☐ Mobile (Type)

Send mail to: ☐ Current Address ☐ Permanent Address

Email Address(es)

COLLEGE/UNIVERSITY STUDENT

Category: ☐ Undergraduate ☐ Graduate/Post-Graduate

Degree(s) Sought/Obtained

Name of College/University | Campus

MIDDLE / HIGH SCHOOL STUDENT

☐ I am a Middle Schooler in: ☐ 6th Grade ☐ 7th Grade ☐ 8th Grade

☐ I am a High School: ☐ Freshman ☐ Sophomore ☐ Junior ☐ Senior

Name of School

Approximate Date of Graduation (MM / YYYY)
(For High School and College/University students, application must include approximate date of graduation to be processed.)

If you were referred by someone, please list name(s), chapter, division, etc.:

WSO Member: __________

WSO Chapter/National Office: __________

WSO Division/Committee: __________

Other: __________

What Interests You?

Please specify your area(s) of interest. These areas of interest will allow you to connect with others who share similar interests throughout the world.

[ ] Occupational Safety and Health (OS&H)
[ ] Environmental Safety and Health (EH&S)
[ ] Fire Safety/Science (FS&S)
[ ] Safety/Loss Control Science (S&LC)
[ ] Public Safety/Health (PS&H)
[ ] Construction Safety (CS)
[ ] Transportation Safety (TS)
[ ] Industrial Hygiene (IH)
[ ] Product Safety (PRO)
[ ] Risk Management (RM)
[ ] Hazardous (Toxic) Materials Management (HAZ)
[ ] Nuclear Safety (NS)
[ ] Aviation Safety (AS)
[ ] Ergonomics (ERG)
[ ] Petroleum (PS)
[ ] Oil Wells (OW)
[ ] Other: __________

Required Signatures & Permissions

I subscribe to the above record and when approved will be governed by the Constitution and By-Laws of WSO and its Code of Ethics as I continue as a member. I furthermore agree to promote the objectives of the WSO wherever and whenever possible.

X
Applicant Signature | Date

FOR MID/HIGH SCHOOLERS ONY: WSO subscribes to the Family Educational Rights and Privacy Act (FERPA) philosophy in protecting student privacy and information. WSO may disclose "directory" information such as a student's name, WSO Student Chapter affiliation, name of school, grade in school, etc., along with group or individual photos in WSO NewsLetters, NewsFlashes, eNews, on WSO website, and on WSO's social media accounts.

☐ My student has permission to participate as outlined above.

☐ My student has permission to participate with exclusions:

X
Parent/Guardian Signature (Mid/High Student) | Date

X
WSO Student Chapter Mentor Signature | Date
[IF APPLICABALE]

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Mr. Binh Pham, Director
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Website: www.worldsafety.org.vn

World Safety Organization

Code of Ethics

Members of the WSO,
by virtue of their acceptance of membership into the WSO,
are bound to the following Code of Ethics
regarding their activities associated with the WSO:

Members must be responsible for
ethical and professional conduct in relationships
with clients, employers, associates, and the public.

Members must be responsible for professional competence in
performance of all their professional activities.

Members must be responsible
for the protection of professional interest, reputation, and
good name of any deserving WSO member
or member of other professional organization involved in
safety or associate disciplines.

Members must be dedicated to professional development of new
members in the safety profession
and associated disciplines.

Members must be responsible
for their complete sincerity in professional service to the
world.

Members must be responsible for continuing improvement and
development of professional competencies
in safety and associated disciplines.

Members must be responsible
for their professional efforts to support the WSO motto:

"Making Safety a Way of Life…Worldwide."

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